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CHARLES ALEXANDER RICHMOND.
President of Union College, 1909–

CHARLES ALEXANDER RICHMOND.

President of Union College.

Charles Alexander Richmond, the twelfth president of Union College, was born in New York City, of Scotch parents, January 7, 1863. His family moved to Orange, New Jersey, ten years later. He received his scholastic training at the Orange Military Academy. From here he entered the College of the City of New York but after one year went to Princeton, from which he graduated A.B. in 1883, winning at the same time a prize in the department of philosophy. He next taught school, but gave this up to enter the Princeton Theological Seminary, from which he was graduated in 1888 and in the same year was ordained in the Presbyterian ministry. His first pastorate was in East Aurora, New York, where he stayed six years, leaving to go to the Madison Avenue Church in Albany, where in 1909 he received the call to the presidency of Union College. In 1891 he was married to Sarah Cooper Locke of Buffalo.

Dr. Richmond had shown marked ability in the ministry as an organizer and as a speaker. His social charm had given him a wide acquaintanceship, as had his interest in music and in athletics. These were the qualities which the trustees felt would make his leadership at the college a success and their judgment has been vindicated far beyond their most sanguine hopes.

The college had been recovering from a long period of depression which at one time reached a point where many alumni and even trustees thought it might be necessary to close the doors. This happily was averted by the work of a relatively small group of loyal Union men at whose head stood President Richmond's predecessor, Andrew Van Vranken Raymond. Their efforts made it possible to turn over to Dr. Richmond an institution with a half million dollars endowment, free of all indebtedness, a student body of a little more than two

hundred fifty, and a faculty of twenty-four. In cannot be said the alumni were enthusiastic about the future of the college, but old quarrels had been laid and they were ready to renew active support when properly led.

We mention these facts that the reader may understand the problem President Richmond faced as well as his success in dealing with it. In the sixteen years which have elapsed since that time the college has been restored to much of its former high reputation. The endowment has been increased until it is now past the three million mark. Nearly a million dollars have been added in new buildings and equipment. The student body has grown until two years ago it was found necessary to limit entering classes that the undergraduate registration should not exceed seven hundred. The faculty to-day numbers sixty-five. These cold figures, however, tell the story of President Richmond's work very inadequately. Numbers have never been his objective. His aim rather has been to develop an institution in which the quality of the work and the personal equation in teaching should be emphasized. He sought to maintain a close relationship between the students, the president, and the faculty in which sympathy and understanding of each other's efforts should be characteristic. His motto in the vexed field of student activities has been moderation; not the sort that comes from arbitrary restraint, but that which comes from active support of what is good and friendly warnings against extremes. His own home is always open to students.

Dr. Richmond's policy with the faculty is to select the best men he can find and give them a free hand in working out their educational problems. He was not trained as a professional educator and leaves the technique of education entirely to his faculty. He has, however, sought to develop the college in a well-rounded manner and in spite of unique opportunities in the field of pure and applied science has always insisted that these departments should not run away with the college, though in building up the institution he gave them first his attention. Thanks very largely to this policy, Union

to-day retains its century-old balance between technical and non-technical courses and the student body is about equally divided between candidates for the A.B. degree and those seeking degrees in science and in engineering.

President Richmond is a keen lover of the beautiful and as a result has directed with special care the development of Union's fine old campus. He has seen to it that new buildings as well as alterations have harmonized with the original plans, which, unfortunately as in the case of so many of our colleges, were disregarded by college authorities during the period when bad architectural taste was so common in America. Certain landmarks of those unfortunate days still remain to mar the beauty of the original conception as laid out for the college in 1813 by the French architect and landscape gardener, Jacques Ramee, but the President's work of restoration and development has reduced them to a minimum, so that not least among his accomplishments must be counted the beautiful physical environment he has created.

President Richmond's wit coupled with unusual good sense has made him in great demand as a public speaker. This coupled with his splendid work as president of the college has earned for him a considerable reputation in educational circles. He served during the war as educational director for the S. A. T. C. in New York and New Jersey. He has also served as president of the Association of American Colleges. He holds the following degrees: D.D., Hamilton College, 1904; LL.D., Rutgers College, 1909; New York University, 1910; Princeton University, 1915; University of Pittsburgh, 1918; George Washington University, 1921, and University of St. Andrews, Scotland, 1924.

THE THIRTY-THIRD ANNUAL MEETING.

UNION COLLEGE, JUNE 16–20, 1925.

The last annual meeting of the Society held at the University of Colorado had the largest attendance in the history of the Society and was one of pleasing surprises, not only in point of attendance, but also in point of program and social activities. The annual meeting crystallizes the activities of the Society for the current year. Those who have the good fortune to attend derive an inspiration obtained in no other way.

The policy of the Society provides an opportunity for the attendance, over a period of years, of members from all parts of the country without excessive cost. However, one striking fact is noticeable. For instance, last year a number of members coming from the East took their vacation in the Rocky Mountains after the convention was over. This year we may expect that there will be a large number coming from the West who will take their vacations in the eastern part of the United States. The added factor, which the Council had in mind in fixing the place and the date, was the fact that the American Institute of Electrical Engineers and the American Society of Testing Materials will hold their annual meetings the following week in nearby cities.

The Council at the Boulder meeting limited the time of the regular meeting. This was done in view of the successful conference held on mining at Golden preceding the annual meeting at Boulder. Conferences have been arranged on research, industrial engineering, electrical engineering, English, and a meeting of the Division of Deans and Administrative Officers on Tuesday and Wednesday preceding the regular meeting.

The efforts of the Board of Investigation and Coördination have reached such a point that we may expect very interesting and valuable data to be presented at the annual meeting.

Mr. Wickenden will be back from Europe with certain data gathered in his investigation of European institutions and also the different committees which have been working with Mr. Hammond will present various phases of engineering education in this country. The whole day, Thursday, has been set aside for the report of the Board and for the discussion of this report.

The Relation of Engineering Education to Industry will be discussed at the Friday morning session by a number of prominent industrialists and engineering educators. In view of the fact that the meeting is being held at Schenectady where the General Electric Company and other industries employ a large number of engineering graduates, it seemed advisable to the Program Committee to discuss again this topic which was thoroughly presented at the Cornell meeting. No meeting has given better promise of definite results and greater possibilities for intelligent discussion than has the coming annual meeting. A large attendance seems to be assured.

THE CONFERENCES ON ENGLISH.

Two conferences on English have been arranged as part of the program of the Schenectady meeting of the S. P. E. E. To the first, scheduled for 2:00 P.M., Wednesday, June 17, the Committee on English invites all who are interested in the problem of better English for our engineering students. In thus extending the invitation, the Committee has no desire to stampede the convention, although the interest at Boulder in our joint conference with the deans was so great as to be most encouraging, but the Committee does wish to give as large an opportunity as possible for everyone to discuss this very vital subject. The second session of the conference on English will be a breakfast-meeting at 7:30 on Saturday morning and is intended to afford the teachers of English themselves a chance to confide their mutual problems to each other in a somewhat more private and intimate fashion. As in previous years, the Committee on English will also be in practically continuous session and will be glad to confer with anyone interested in advising with them regarding specific problems of English teaching.

The Committee has for the past two years been making a systematic survey of the status of English teaching in the engineering schools. The development of this phase of engineering education is as yet so new and in so largely an experimental stage that it is too early to generalize, but the Committee has felt that a carefully drawn cross-section of the status of English in our technical schools might be useful as a contribution to the work Mr. Wickenden has undertaken and as a basis for constructive effort on the part of everyone interested in making our instruction in English more efficient. This survey, while not complete, is in form to report and will be the basis for discussion at the two conferences.

The outline of the general plan of the survey is given below, in order that those who expect to attend the conferences at

Schenectady may come prepared to contribute to the discussion.

SURVEY OF THE STATUS OF THE TEACHING OF ENGLISH.

I. Classification of Freshmen.
   A. On entrance.
      1. By examination.
      2. By week of test work.
   B. At the end of a probational period.
      1. Two weeks.
      2. Six weeks.
      3. Eight weeks.
   C. After postponement of English 1.
      1. To the second semester.
      2. To the second year.

II. Supplementary Work.
   A. To precede English 1—Sub-freshman work.
   B. To accompany English 1—Supplementary work.
   C. To follow English 1—Make-up work.

III. Courses in English Composition.
   A. Required courses.
      1. English 1. 2. Follow-up work.
   B. Elective courses.
      1. General.
      2. Specialized courses.
      3. Business English, Commercial Correspondence. Reports, Scientific Papers, Technical Journalism.

IV. Courses in Literature.
   A. Systematic courses in the history of literature.
      1. English. 2. American.
   B. Courses in the appreciative and critical study of modern literature.
      1. General introductory courses.

2. Foreign literature courses in English.
3. Special courses in the drama, novel, short story, and scientific literature.

C. Supplementary reading lists.

V. Combination Courses.

A. English and History.
B. English and Economics.
C. English and Government.
D. English and Logic.

VI. Plans for Checking Students' Careless Habits of Expression.

VII. Plans for Securing Coöperation of Entire Faculty.

VIII. Senior English Courses.

The Committee will appreciate material bearing on any of the lines of investigation covered. Send all such material to the Chairman, J. Ralph Nelson, 927 Forest Ave., Ann Arbor, Michigan.

CORRELATION OF THE EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD WITH COLLEGE STANDING.

BY CARL C. BRIGHAM,

Associate Professor of Psychology, Princeton University.

PART I.

Statistical Methods.

The writer has accumulated, during the last three years, a certain amount of data concerning the examinations of the College Entrance Examination Board. The data were collected incidentally in the course of a larger study. He had planned to present them for the information of interested persons in a brief, skeleton form. The editors of this magazine were good enough to suggest that the data would be more useful if introduced by an explanatory article describing the technique of the statistical methods used. The entire article has been divided into two parts, Part I, in this issue, being devoted entirely to a description of statistical methods. Part II will present the data concerning the examinations themselves.

Averages and Deviations.

Academic grades are frequently designated by the letters A, B, C, D, E, and F, or A, B, C+, C, C—, and D, or by five grades of merit designating passing and one grade designating failure. There are thirty six possible combinations of the grades A, B, C, D, E, and F for two terms or semesters in one course–A + A (A both terms), A + B (A first term and B second term), B + A (B first term and A second term), and so on. Certain combinations such as B + F, F + B, C + E, E + C, and D + D have the same average value. If we place all combinations of equal value together, the full year grades fall into eleven groups on a scale of merit as follows:

					A+F						
				B+F	F+A	A+E					
			C+F	F+B	B+E	E+A	A+D				
		D+F	F+C	C+E	E+B	B+D	D+A	A+C			
	E+F	F+D	D+E	E+C	C+D	D+B	B+C	C+A	A+B		
F+F	F+E	E+E	E+D	D+D	D+C	C+C	C+B	B+B	B+A	A+A	

(Lowest) (Highest)

These thirty-six possible combinations of six grades for two terms give a scale of eleven points, which may be designated by the letters above, or turned into a numerical system. If F were 1, and A were 6, the eleven combinations would be expressed on a scale from 2 to 12. To illustrate the methods of treating academic marks, we will assume that the grades given to 62 men in any full year (two term) course were distributed in the following manner:

Sum of grades	2	3	4	5	6	7	8	9	10	11	12
No. of cases	1	3	5	7	9	12	9	7	5	3	1

The average grade may be obtained by multiplying each grade by the number of cases (or frequencies) at each grade, and dividing the sum of these products by the number of cases, as follows:

12 × 1 =	12
11 × 3 =	33
10 × 5 =	50
9 × 7 =	63
8 × 9 =	72
7 × 12 =	84
6 × 9 =	54
5 × 7 =	35
4 × 5 =	20
3 × 3 =	9
2 × 1 =	2
Sum	434

$$\frac{\text{Sum}}{\text{No. of cases}} = \frac{434}{62} = 7 \text{ the average or mean.}$$

This process of finding the average is simply a short-cut

method of adding a list of 62 numbers: $2+3+3+3+4+4+4+4+4$, etc.

Having once found the average, we may disregard the scale of numbers from which the average was obtained by calling the average zero, and regarding the other numbers as deviations above and below the average. The distribution of grades given above may be written:

Deviations	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
No. of cases	1	3	5	7	9	12	9	7	5	3	1

The conversion of grades into positive and negative deviations from the average is a very common statistical device, and has many desirable features. Diverse types of marking systems may be made comparable by this simple method. Another feature arises from the practical desirability of using small numbers in calculations instead of large ones. If we are dealing with percentage grades, for instance, and the number of cases is large, no great error is introduced by grouping the data into class intervals such as 40 to 44, 45 to 49, 50 to 54, 55 to 59, etc. If the percentage grades run approximately uniformly, and they can be grouped into class intervals expressing somewhere from twelve to twenty grades of ability, they may be treated conveniently by grouping, calling the average zero, and treating the remaining groups as positive or negative deviations of 1, 2, 3, etc., from the average. Other features of the method will be discussed later.

The Standard Deviation.

There is one very great difference between the novice and the statistician in the treatment of academic marks or any other series of measures. The novice always thinks of a series as being determined by its *average*, while the statistician thinks of the series in terms of its *average and its variability*. Take the following two series for example:

Series I.

Sum of grades	2	3	4	5	6	7	8	9	10	11	12
No. of cases	1	3	5	7	9	12	9	7	5	3	1

Series II.

Sum of grades	2	3	4	5	6	7	8	9	10	11	12
No. of cases	1	2	3	5	9	22	9	5	3	2	1

In both of these series, the average grade is the same—seven—but the two series differ markedly in the manner in which the cases distribute themselves on the scale. The cases are much more closely packed around the average in Series II. The statistician thinks of a series as scattered more or less widely about an average, and must have a measure of *dispersion*. He frequently draws a curve or graph of the distribution, but he needs a number which describes it more accurately.

The standard measure of variability is variously called "the standard deviation," the "mean square deviation," or "sigma." The definition of the standard deviation is alarming, but its computation is a very simple arithmetical process. After the average has been obtained, this is called zero, and the other grades are treated as deviations from this average. The computation of the standard deviation then uses the squares of these deviations instead of the deviations themselves. The computation is described in the following sample:

Sum of Grades.	No. of Cases.	Deviations from Average.	Square of Deviation.	Deviations Squared Times No. of Cases.
12	1	+5	25	25
11	3	+4	16	48
10	5	+3	9	45
9	7	+2	4	28
8	9	+1	1	9
7	12	0	0	0
6	9	−1	1	9
5	7	−2	4	28
4	5	−3	9	45
3	3	−4	16	48
2	1	−5	25	25
Sum	62			310

The standard deviation is obtained from the sum of the products of the squares of the individual deviations and their frequencies by dividing this sum (310) by the number of cases, and taking the square root of that answer. In this example, the process is as follows:

$\frac{310}{62} = 5$. The square root of 5 is 2.236 the standard deviation, or sigma.

If the series of numbers given as Series II above be calculated, it is found that the summation of the products of the deviations squared times the frequencies is 226 and sigma is 1.909. The difference between 2.236 and 1.909 is the measure of the difference in the spread or scatter of the two distributions.

The standard deviation is defined as the square root of the average of the sums of the squares of the individual deviations from the average of the series. The formula is written:

$$\sigma = \sqrt{\frac{\Sigma d^2}{n}}.$$

This value of the standard deviation is as important as the average, for it defines the variability or amount of dispersion of the measures.

Correlation.

It sometimes becomes necessary to compare two sets of grades or measures of the same group of individuals. A college professor might write a final examination at the end of his course to measure the attainment of his students in the subject matter of the course. It is conceivable that he might doubt his ability to make this measurement. If so, he might obtain an index of the reliability of his measurement by writing another parallel paper, and by giving it to the same men the next day. He would then want to compare the relative standing of the same men on the two papers. The coefficient of correlation would enable him to do this.

It is possible to construct a table showing how each individual stands in two sets of measures. Such a table is shown in Fig. 1.

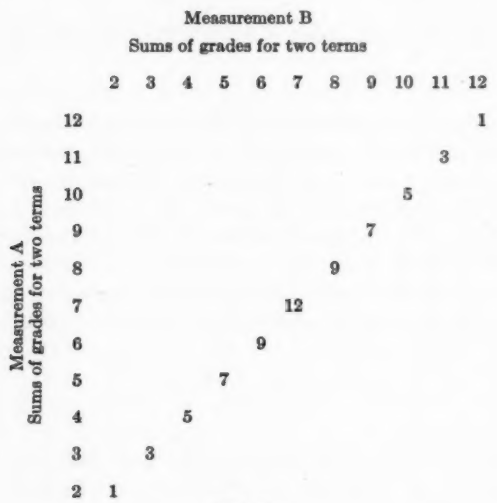
Measurement B
Sums of grades for two terms
2 3 4 5 6 7 8 9 10 11 12
12 1
11 3
10 5
9 7
8 9
7 12
6 9
5 7
4 5
3 3
2 1
Measurement A
Sums of grades for two terms

FIG. 1.

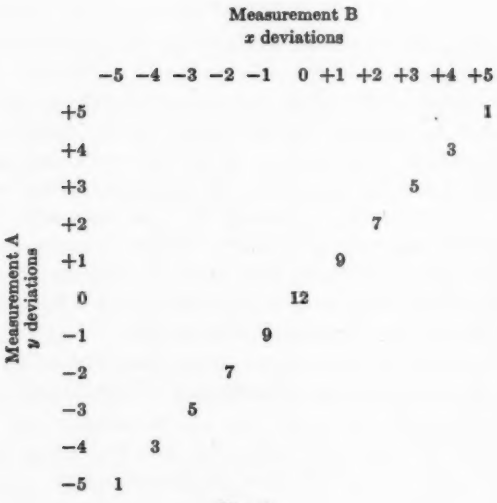
Measurement B
x deviations
−5 −4 −3 −2 −1 0 +1 +2 +3 +4 +5
+5 1
+4 3
+3 5
+2 7
+1 9
0 12
−1 9
−2 7
−3 5
−4 3
−5 1
Measurement A
y deviations

FIG. 2.

Fig. 1 shows a state of perfect correspondence. The one man who stands at the top in Measurement A also stands at the top in Measurement B. Three men in second place in one measurement are also in second place in the other measurement. And so forth, step by step throughout the table, perfect correspondence is shown. If such a condition really existed, it would be unnecessary to make Measurement B if A had previously been made.

Figure 1 may be re-written in terms of deviations from the average as in Fig. 2. The only difference between Fig. 1 and Fig. 2 is in the numbering system along the horizontal and vertical margins. The average of each series is seven, this is called zero, and the other grades are expressed as positive and negative deviations from zero.

There are three sets of facts which are necessary in obtaining a quantitative expression of the amount of correspondence between two series of measurements: (1) the variability of grades in Measurement A, (2) the variability of grades in Measurement B, and (3) the relative positions of deviations of the same individual from the two averages.

For the measurement of variability, we have already shown how the standard deviation is computed. The value of sigma for both Measurement A and Measurement B is 2.236. Inasmuch as we must necessarily have the same number of cases in both measurements, we may take as the expression of variability in each series either (1) the standard deviation, or (2) the summation of squares of the individual deviations (Σd^2). We may call each deviation from the average in Measurement A an x-deviation, and each deviation from the average of Measurement B a y-deviation. To obtain an index of the relative position of one individual from the average of the two measures, we multiply his x-deviation by his y-deviation. This may be done for each of the 62 individuals shown, and the summation of all these $x \cdot y$ products obtained. If we carry through this arithmetical process, we have the result shown in Fig. 3. The first case in the upper right-hand corner deviates +5 from one average and +5 from the other

average, the $x \cdot y$ product being 25. In the next box, there are three men who deviate +4 from each average, the $x \cdot y$ product being 16, or a total of 48 for the three cases.

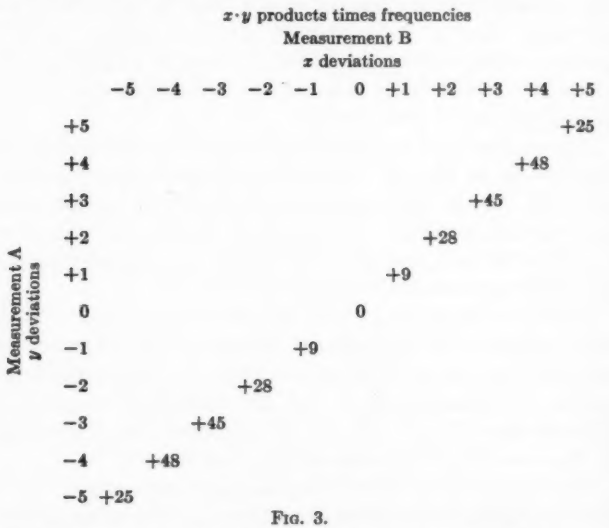

FIG. 3.

It is obvious that in the particular case of perfect correspondence shown, the process of multiplying x and y deviations is nothing more than the process of squaring deviations in either series. The summation of $x \cdot y$ products in Fig. 3 is 310, which is the same value as the summation of the squared deviations in either Measurement A or Measurement B.

One figure may be obtained expressing the degree of correspondence by using a ratio in which the figure obtained by summing $x \cdot y$ products is divided by what would be obtained in case of perfect correspondence. Inasmuch as perfect correspondence amounts to nothing more than summing squares, the value expressing the variability of both series is

$$\sqrt{\Sigma x^2 \cdot \Sigma y^2}.$$

The ratio for the condition shown in Figs. 1, 2 and 3 is

$$\frac{310}{\sqrt{310 \times 310}} = 1.00.$$

The correlation ratio or coefficient of correlation (called r) may be written

$$r = \frac{\Sigma x \cdot y}{\sqrt{\Sigma x^2 \cdot \Sigma y^2}}.$$

It is sometimes written

$$r = \frac{\Sigma x \cdot y}{n\sigma_1\sigma_2}.$$

This is the same thing, for the formula for the standard deviation or sigma is $\sqrt{\frac{\Sigma d^2}{n}}$, and

$$n \times \sqrt{\frac{\Sigma x^2}{n}} \times \sqrt{\frac{\Sigma y^2}{n}} = \sqrt{\Sigma x^2 \cdot \Sigma y^2},$$

for n simply cancels out. Arithmetically, from the example given $62 \times 2.236 \times 2.236 = 310 = \sqrt{310 \times 310}$.

The coefficient of correlation is simply a device for comparing, by means of a ratio, actual findings, as obtained by summing $x \cdot y$ products, with expected findings if perfect correspondence obtained. If inverse correlation held, the line of numbers in Fig. 1 would run down from the upper left-hand corner to the lower right-hand corner. The $x \cdot y$ products would all be negative, however, so the answer would be —1.00.

Another example of correlation is given in Fig. 4. Here the relationship is close, but perfect correspondence is not present. The $x \cdot y$ products times the number of cases in each box of Fig. 4 are given in Fig. 5. The summation of $x \cdot y$ products in this instance is 284, and the ratio is

$$r = \frac{284}{\sqrt{310 \cdot 310}} = .916.$$

Correspondence as close as this is rarely found in educa-

Measurement C: Sums of grades for two terms	Measurement D: Sums of grades for two terms											
	2	3	4	5	6	7	8	9	10	11	12	Tot.
12										1		1
11									1	1	1	3
10								1	3	1		5
9						1	3	2	1			7
8						3	3	3				9
7				1	3	4	3	1				12
6				3	3	3						9
5			1	2	3	1						7
4		1	3	1								5
3	1	1	1									3
2		1										1
Tot.	1	3	5	7	9	12	9	7	5	3	1	

FIG. 4

tional measurements, but tests for measuring intelligence, when properly built, usually correlate as highly when repeated. The conventional practice in testing the reliability of a test by repetition is that of building two alternate forms. The group to be examined is divided into two sections, and the experiment arranged so that one half takes Form A the first day and Form B the second day, the other half taking Form B the first day and Form A the second day. Under these conditions, practice from form to form is constant, and inequalities in the difficulties of the forms are distributed equally between the two groups. The correlation between scores obtained by the same individuals on separate days will range from .85 to .92 when good tests are used. There is, of course, no reason why college professors could not test the reliability of their methods of examining by the same technique, but they rarely do so. It is easier to *assume* absolute reliability, or a correlation of 1.00 between successive trials

of the measuring instrument, than it is to test the reliability of the instrument by the method outlined.

$x \cdot y$ products times frequencies

Measurement C y deviations	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
	Measurement D x deviations										
+5										+20	
+4									+12	+16	+20
+3								+6	+27	+12	
+2							+6	+8	+6		
+1							+3	+6			
0											
−1				+6	+3						
−2			+6	+8	+6						
−3		+12	+27	+6							
−4	+20	+16	+12								
−5		+20									

FIG. 5.

A short-cut method of determining the reliability of an examination has been invented. It involves the correlation of random halves of the same paper, or odd and even numbered questions of one paper. It is thought by some statisticians that the coefficients obtained by this method can be made comparable with coefficients obtained by the longer process of repeating the examinations. The evidence so far collected on this question, shows that the short-cut method works fairly well in examinations written for school children, but at Princeton by testing the same data both ways we find no correspondence justifying the use of the short-cut method as a substitute for the actual repetition. We learn something from the use of both methods, but we do not feel warranted from the evidence we have on the point in assuming that the split half test of reliability will give even a reasonable ap-

proximation of the true coefficient obtained by re-testing the group.

Measurement E: Sums of grades for two terms	Measurement F: Sums of grades for two terms											
	2	3	4	5	6	7	8	9	10	11	12	Tot.
12											1	1
11						1	2					3
10							1	1	1	2		5
9				1	1	2	2	1				7
8			2	1	1	1	1	1	1	1		9
7				2	3	2	2	2	1			12
6		1		2	2	2			2			9
5			1	1	1	1	1	2				7
4			1		1	3						5
3	1	1	1									3
2		1										1
Tot.	1	3	5	7	9	12	9	7	5	3	1	62

FIG. 6.

Another example of correlation is given in Figs. 6 and 7. There is a general tendency for the cases to distribute along the diagonal line, which may be imagined as running from the lower left-hand corner to the upper right-hand corner, but the area is wider. One may imagine a correlation plot as an ellipse which may approach the circle in one direction, or a straight line in the other direction. The $x \cdot y$ products from Fig. 6 are shown in Fig. 7. The correlation here is:

$$r = \frac{164}{\sqrt{310 \cdot 310}} = .529.$$

Still another example of correlation is given in Figs. 8 and 9. These figures show what approximates a random scatter

$x \cdot y$ products times frequencies

Measurement F

x deviations

Measurement E, y deviations	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
+5											+25
+4							+8				
+3							+3	+6	+9	+24	
+2				−4	−2		+4	+4			
+1			−6	−2	−1		+1	+2	+3	+4	
0											
−1		+4		+4	+2				−6		
−2			+6	+4	+2		−2	−8			
−3			+9		+3						
−4	+20	+16	+12								
−5		+20									

FIG. 7.

Measurement H

Sums of grades for two terms

Measurement G, Sums of grades for two terms	2	3	4	5	6	7	8	9	10	11	12	Tot.
12								1				1
11					1		1			1		3
10			1	1			1		1		1	5
9	1		1		1		1	1	1	1		7
8		1	1	1	1	1	1	1	1	1		9
7		2	2	1	2	1	1	1	2			12
6				2	2	2	2	1				9
5				1	2	4						7
4				1		2	1	1				5
3						1	1	1				3
2						1						1
Tot.	1	3	5	7	9	12	9	7	5	3	1	62

FIG. 8.

of cases throughout the boxes. The $x \cdot y$ products are shown in Fig. 9.

$x \cdot y$ products times deviations

Measurement G y deviations	Measurement H x deviations										
	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
+5								+10			
+4					−4		+4			+16	
+3			−9	−6			+3		+9		+15
+2	−10		−6		−2		+2	+4	+6	+8	
+1		−4	−3	−2	−1		+1	+2	+3	+4	
0											
−1				+4	+2		−2	−2			
−2			+4	+4							
−3			+6				−3	−6			
−4							−4	−8			
−5											

Fig. 9.

The coefficient of correlations here is:

$$r = \frac{35}{\sqrt{310 \cdot 310}} = .113.$$

It is apparent that if the situations causing scores in two measurements are unrelated, there will be as many negative as positive $x \cdot y$ products, so that the correlation will tend to become zero, since the positive and negative products will cancel. The correlation coefficient has been rightly called a coefficient of "mutual implication." It expresses relationship on a scale running from —1.00 to +1.00.

The examples cited are all arranged so that the standard deviation is the same in both series of measurements. This never holds true in practice, but does hold approximately true when we correlate the same sorts of measures—academic

grades with academic grades, etc. The formula for the correlation coefficient uses in the denominator either sigma or the summation of the squares of the deviations of both series of measurements, so that differences in variability are compensated.

In the examples cited, the cases may be imagined as falling along a straight line running from the lower left-hand corner to the upper right-hand corner. This straight line relationship usually holds in educational measures. If it does not hold, the formula for the coefficient of correlation which is given here will not work. One may imagine cases as compactly clustered as in Fig. 4, but following a curve instead of a straight line. If such a situation occurs, it is necessary to use other methods in calculating the coefficient. Properly, all data should be tested to see if they can be treated as rectilinear, but this is not often done. Correlation coefficients as derived from data obtained in educational measurements are rather crude indexes of the relationships holding, and the data do not justify too much effort.

The common practice has been to accept the judgment of the individual investigator that his data are approximately rectilinear, and let it go at that. If an examination for entrance, let us say, is arranged so that it differentiates the lower end of the scale—from 50 to 0—more effectively than the upper end of the scale, and if this examination is correlated with academic grades where the possibility of a high average is much greater, then the ungraded cases at the upper end of the entrance measure will distribute themselves in the academic grades, and one finds a curvilinear relationship. Everyone using correlation coefficients should be alive to this situation, and should use the proper methods for treating such data.

The accuracy of the correlation coefficient, or its stability, is a function of the number of cases on which the coefficient is based and of the size of the coefficient. Coefficients are usually written with their "probable error"—which is neither probable nor an error. The probable error is an estimate of

the range within which the true coefficient would most likely fall. If the coefficient is .35 ± .05, the chances are fifty-fifty that the true coefficient is between .30 and .40, with chances still present but increasingly less likely that it is greater than .40 or less than .30. The formula for the probable error of the coefficient of correlation is written:

$$\text{P.E.}\, r = .67449 \frac{1 - r^2}{\sqrt{n}}.$$

The conventional practice is to write the coefficient with the probable error and the number of cases on which it was based. The range of the most probable guess as to the location of the true coefficient may then be very readily made by the reader.

The greatest stumbling block in the way of interpreting results of correlations by persons who are unaccustomed to their use is the difficulty of understanding the effect of general improvement on one series of measures over another series. *The fact is that general improvement does not change the coefficient at all.* For instance, if we correlate standing in Freshman Latin with standing in Sophomore Latin, and if in the Sophomore year all members of the class did very much better than in their Freshman year, the average grade would show the difference, but the correlation coefficient would not change unless the *relative* positions of the men in the two courses changed.

This situation holds because the average on each series is called zero, and the cases are treated as plus or minus deviations from zero. The average may move up or down any number of points and still be called zero. The correlation coefficient does not measure improvement—that is measured by comparing averages—but relative changes in position. By reference to Fig. 4, it may be seen that any series of numbers could be written along the left and top edges of the table, and still be treated as in Figure 5 where the middle point of each series is called zero. Improvement causes no change in the coefficient. Changes in the coefficient are caused by changes in relative position as shown in Figs. 4, 6 and 8.

Another very difficult matter to interpret is that of the size of the coefficient. When is a coefficient of correlation high enough to be significant? The answer to this question is involved in the question of *range* or selection of cases. If we correlate height and weight of college students, we find the correlation about .50 or .60. But, most college students are from seventeen to twenty-three years of age, and their period of most rapid physical growth has taken place. It is obvious that if we correlate height and weight of 1,500 children, taking 100 cases from each age group from one to fifteen, the coefficient would be much higher. The coefficients obtained must, therefore, be interpreted in the light of the selection of the group. It has become common practice in educational work with school children to calculate coefficients of correlation between measures for unselected age groups. Instead of pooling all examinations of children of all ages, one calculates a coefficient for all twelve-year children, all eleven-year children, etc. By accumulating data of this sort, one has data for comparing the spread or dispersion of the groups from the values of the standard deviations obtained.

Selective factors most certainly operate in determining the size of coefficients of correlation obtained from comparing entrance examinations with college standing. Here, a considerable portion of the group is excluded from college, and we may compare entrance marks with academic standing only for admitted men. If we know (1) the value of the standard deviation for all men who took the examination, (2) the same value for admitted men, and (3) the correlation between entrance examinations and academic marks for admitted men, we may estimate the most probable coefficient which would have been obtained if all men had been admitted. But this coefficient is simply the most probable one, not the real one, and there are many possibilities of error in its use. Actually, it is not necessary to find this coefficient. The method of correlation is particularly useful in comparing the relative efficiency of different types of examinations, and coefficients may be compared with each other as long as the principles of selec-

tion of the groups from which they were obtained hold constant. The values of the means and sigmas found enable one to judge the selective factors. As a general rule, it is best for the amateur to use actual or "raw" coefficients of correlation, and let the expert who understands the limitations of the methods apply the so-called "corrections."

One generalization is possible in estimating the size of coefficients of correlation found between entrance examinations and college standing—the higher the coefficient, the less the amount of injustice done in rejecting candidates. If we were able absolutely to measure a candidate's ability to do college work, no injustice would be done. Actually, we are far removed from this desideratum. Every college admits many men unable to do the work of the college, and rejects men who are entirely competent. Where there is a limitation of enrollment, a certain number of potentially able students are always rejected in favor of students who never can do the work of the college.

One may imagine that Measurement C in Fig. 4 is a scale of marks obtained from entrance examinations, and that Measurement D is an average of academic grades. What happens when a faculty committee legislates a fixed passing mark for entrance? If the entrance passing mark for Measurement C were fixed at 8, the results may be seen by cutting through the plot between 8 and 9 with scissors. If academic grades of 9 were satisfactory, and 10, 11 and 12 represented failure, then every one of the admitted men would pass, and 7 of the 16 rejected applicants would have passed if admitted. This is not a bad result, but the correlation between Measurements C and D is above .90, which is much higher than is found in educational measurements. A truer picture of college entrance is found in Fig. 6 where the correlation between the two measures is nearer .50. A similar selection here would admit 3 men out of 46 who failed, and reject 10 out of 16 who would have passed if admitted.

Academic legislatures in enacting entrance requirements seem to assume that a correlation between these examinations

and subsequent standing holds similar to that shown in Fig. 2, or, perhaps, Fig. 1. They seem to feel that it is only necessary to legislate higher standards in order to get better men. These legislatures should be taught that in setting fixed passing marks they are simply cutting through a correlation plot with a pair of scissors, and that with existing measures, they do a considerable amount of damage. Under existing conditions, college admission is a matter of betting on certain individuals more heavily than on others. The size of the coefficient of correlation expresses, in a general way, the validity of the betting system each college adopts.

The method of correlation enables one to try out—on paper—various types of entrance methods. If we have several types of examinations of the same group of individuals, and a record of their academic achievement, we may calculate the correlation between each of the various types of examination and academic marks, and we may also correlate each of the types of entrance examination with each other. We then have a table of inter-correlations of entrance tests. Such a table enables us to try various cut-and-fit methods of combining examinations. Knowing the correlation of two tests with college work, and the correlation of the two tests with each other, we may obtain a coefficient expressing the correlation of the two tests together with college marks. For instance, the correlation of the Old Plan examinations of the College Entrance Examination Board with two years academic work at Princeton is .50; the correlation of the psychological test with two years standing .56; and the correlation of the psychological test with the College Board examinations .40. The correlation of both types of examinations with college standing may be found as follows:

$$r = \frac{.50 + .56}{\sqrt{2 + 2 \times .40}} = .63.$$

This method is known as multiple correlation. Any number of tests may be combined by multiple correlation, provided

we know their intercorrelations and the correlation of each with the thing it is desirable to correlate against.

The essential point to be remembered in considering multiple correlation is that the final high correlation of the whole group or team of measures with the one thing with which the team should correlate highly depends on two factors, (1) high correlation of each member of the team with the desired measure, and (2) low correlation of each member of the team with each other member. This really means that we measure a thing most accurately when we measure it from as many *different* angles as possible.

It is a matter of common knowledge that when several tests or measures are combined, the several members of the combination will work together better if they are weighted, one test being multiplied by two, another by one, etc. The method of correlation enables one empirically to determine the best weights of the several tests so that the final combination will have the maximum correlation with the desired measure. It also enables one to isolate each factor and find the correlation of that factor with the desired measure when all other factors are held constant. This method is known as partial correlation. The basic data for both multiple and partial correlation are tables of intercorrelations of all the variables involved.

The correlation coefficient, in a sense, is a method of *prediction.* We know one thing about an individual—his scores on a series of measurements—and we want to know something which has not yet happened—what he will do in college. A fair notion of what prediction means may be gotten by looking at Figs. 1, 4 and 6. Here, we will imagine that measurements A, C and E are things that are known, or marks in entrance examinations, and measurements B, D and F, the unknown or college standing. Our known measure enables one to place the individual in his correct row or horizontal line. The width or scatter of cases along the horizontal line shows the chances of the individual of making the several possible grades.

In Fig. 1, the nine cases in row 6 make an academic grade

of 6. In Fig. 4, these nine cases make grades of either 5, 6, or 7. In Fig. 6, the nine cases range from academic grades of 3 to 10. When the correlation is high, the row is compact, and the scatter within the row is clustered about the average of the row. When the correlation is low, the spread within the row is much wider. The fact is that the cases in any given row will distribute themselves along a certain series of grades, and that this distribution within the row may be described by its mean and standard deviation just as any other total distribution may be described. The coefficient of correlation enables us to estimate the amount of dispersion within the row. This is simply another method of stating the relative certainty of the betting chances. The betting is more certain if the correlation is high. The betting is none too good when the correlation is .50, but colleges do most of their betting in this region.

There are plenty of reasons why a high correlation should not obtain between entrance examinations and college standing, which are quite independent of the nature of the entrance examinations. Everyone is familiar with the type of student of excellent ability who makes no effort to exert his ability along academic lines—the distractions prove to be too great to resist. In the same way, illness, worry over home conditions, failure or imagined failure in the social side of college life, hyper-activity along extra-curricular lines, and innumerable other causes have their effect in lowering correlations. But, when one tries out—on paper—various schemes of admission, he finds that certain methods are better than others. The technique of this cut and fit method is that of correlation. If a college finds that a certain method of admission has a correlation of .50 with subsequent standing, and another method .65, then the college would do well to adopt the second method, for the factors making for low correlation are constant in the two cases, and the difference comes only in the measurements which may be made at the time of application for admission.

Another cause of low correlation, which the teacher is usu-

ally unwilling to admit is the unreliability of his marks. But, in spite of the unwillingness of teachers to admit that their methods of measuring and grading attainment in courses are imperfect, one may consider these grades along with most other educational measuring devices as rather crude methods. The proof of this arises from the fact that when honest and intelligent efforts have been made by teachers to improve the reliability of their grades, better results have been obtained. The element of unreliability also enters on the side of the entrance examinations, for these are, as a rule, somewhat crude measuring devices. The test of the reliability of an examination is the correlation between first and second trials of parallel forms as described before. Such coefficients are known as reliability coefficients. The limit of correlation between two variables is the product of the square roots of their reliability coefficients. If two measures correlate with themselves on repetition .81 and .64 respectively, the highest possible correlation between them, except by chance, is .72. These facts should be kept in mind when interpreting coefficients of correlation between two measures neither of which is an absolute or final measure of the attainment which the author of the examination claims he measures.

The writer does not contend that the method of correlation is the cure-all of educational method, nor that everything that can be known about a system of examinations is known when the correlation between the system and subsequent attainment is determined. He merely contends that this technique is very essential to the investigation of the problems involved, and gives part of the essential data on which intelligent action may be based.

For the reader who wishes to pursue the matter further, the following books are recommended:

RUGG, H. O. "Statistical Methods Applied to Education," Boston: 1917, pp. 410. (An easy introduction to the subject with frequent illustrations drawn from educational practice.)

KELLEY, T. L. "Statistical Method," New York, 1923, pp. 390. (A complete reference work of all methods discussed in this paper. The most useful and practical book in the field.)

RIETZ, H. L. (Editor-in-chief). "Handbook of Mathematical Statistics," Boston: 1924, pp. 221. (Discussion of the mathematical problems of statistical analysis by the leading authorities in this country.)

PART II.

PRINCETON DATA.

The following data, giving the correlations between the examinations of the College Entrance Examination Board and academic standing at Princeton University are presented here for the enlightenment of colleges using the examinations of the College Board, and for others interested in problems of college admission.

About two hundred men graduating from Princeton in 1923 and two hundred more graduating in 1924 were selected for one study. The principle of selection was graduation after eight consecutive terms of college residence. As the Princeton academic year of thirty-six weeks is divided into two terms or semesters of eighteen weeks each, selection by graduation after eight consecutive terms of residence gives only those who received their degrees in schedule time, and eliminates all failures and other cases of academic maladjustment. The Princeton curriculum during Freshman and Sophomore years is fairly definitely controlled, with a certain number of required courses supplemented by electives within a limited range. The curriculum during the Junior and Senior years, for the classes of 1923 and 1924, more closely approximated the free elective system. These two periods of the curriculum are, therefore, treated separately. The correlations were as follows:

Correlation between C. E. E. B. weighted average "New Plan" and average of Freshman and Sophomore years ..... $.46 \pm .06$ ($n = 79$)

Correlation between C. E. E. B. weighted average "Old Plan" and average of Freshman and Sophomore years ..... $.39 \pm .03$ ($n = 381$)

Correlation between C. E. E. B. weighted average "New Plan" and average of Junior and Senior years ..... $.37 \pm .07$ ($n = 82$)

Correlation between C. E. E. B. weighted average "Old Plan" and average of Junior and Senior years ..... $.38 \pm .03$ ($n = 392$)

(*Note:* "New Plan" refers to the system of comprehensive examinations, "Old Plan" to the conventional system of separate papers in different sections of the subject. The "weighted average" is that obtained by multiplying the percentages received in the examinations by the unit values of these examinations, and dividing the sum of these products by the total number of units offered. All coefficients of correlation in this report were obtained by the standard products-moments method described in the preceding article.)

The four coefficients above may be considered as equal—as they are within the limits of the probable error. These coefficients are restricted somewhat due to the fact that Princeton accepts only men who have passed practically all of the College Board examinations, and due to the further selection of only those men who graduated after eight consecutive terms of residence. There is no satisfactory method of "correcting" these coefficients from the data on hand. The reduction in sigma due to selection by graduation after eight consecutive terms is very slight. We have no record of the value of sigma for all College Board candidates.

In the case of the Princeton class of 1927, the correlations of College Board examinations with Freshman standing were as follows:

Correlation between C. E. E. B. weighted average "New Plan" and first term Freshman year... $.31 \pm .05$ ($n = 132$)
Correlation between C. E. E. B. weighted average "Old Plan" and first term Freshman year... $.52 \pm .02$ ($n = 447$)
Correlation between C. E. E. B. weighted average "New Plan" and both terms Freshman year.. $.30 \pm .05$ ($n = 127$)
Correlation between C. E. E. B. weighted average "Old Plan" and both terms Freshman year.. $.57 \pm .02$ ($n = 437$)

For our class of 1926, we have calculated correlations of College Board examinations for one, two, three, and four consecutive terms of academic work. These figures are given in Table I.

TABLE I.

CORRELATION OF WEIGHTED AVERAGE IN THE EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD WITH ONE, TWO, THREE, AND FOUR CONSECUTIVE SEMESTERS OF ACADEMIC WORK FOR THE PRINCETON CLASS OF 1926.

	Old Plan.		New Plan.	
	r	n	r	n
First term Freshman year	.52±.03	367	.42±.05	114
First and second terms Freshman year	.49±.03	350	.47±.05	112
Both terms Freshman year plus first term Sophomore year	.53±.03	349	.36±.05	120
Both terms Freshman year plus both terms Sophomore year	.50±.03	310	.40±.06	94

The correlations for the classes of 1926 and 1927 show that the "Old Plan" gives a somewhat closer correspondence with academic attainment than the "New Plan."* It is interesting to compare these coefficients from the College Board examinations of the class of 1926 with similar coefficients obtained from psychological tests. These coefficients are given in Table II.

* It is important to note here that the coefficients given for the "New Plan" refer only to the comprehensive papers and not to the system as a whole. Under the "New Plan" system, the college receives from the College Entrance Examination Board (*a*) the marks on the comprehensive papers, and (*b*) the actual papers written by the candidate. The college also receives from the preparatory school (*c*) the grades of the candidate in each school subject, together with the number of weeks spent in studying that subject, and (*d*) the rank of the candidate in the first, second, third, or fourth quarter of his class. Of the four lines of evidence used for admitting "New Plan" candidates, therefore, our method evaluates only (*a*) the marks on the comprehensive papers. The evidence for "Old Plan" candidates consists only in the marks on the College Board papers. The fact that the weighted average of the comprehensive papers correlates lower with subsequent standing than the weighted average of the larger number of "Old Plan" papers does not prove that the "New Plan" as a whole is less efficient than the "Old Plan." We are proceeding to analyse the factors listed as *b*, *c*, and *d*, but have not completed the study. In the meanwhile, no conclusions concerning the relative merits of the two systems may be drawn from our data.

TABLE II.

CORRELATION OF THREE AND FOUR SEMESTERS OF ACADEMIC WORK WITH SCORES ON PSYCHOLOGICAL TESTS.

	Average Academic Grade for Three Terms.		Average Academic Grade for Four Terms.	
	r	n	r	n
Thorndike test	.43 ± .02	499	.43 ± .03	428
Our test	.48 ± .02	498	.51 ± .02	473
Higher of these two	.53 ± .02	498	.56 ± .02	426

The Thorndike test was given to the class of 1926 at the beginning of the Freshman year, and our own test a year later. Our test consisted of a twenty-one test battery from which certain tests were selected by various criteria among which academic grades were included. These figures, therefore, do not prove that our own tests are any better than the Thorndike test.

The correlation between the Thorndike test and our test in the case of 525 men given both examinations was .72 ± .01. Either of these tests if repeated after a short interval would correlate with itself around .85 or .90. It was somewhat of a surprise, therefore, to find that the two tests correlated only .72 with each other—even with an interval of a year between. However, this figure probably expresses the true situation in regard to different types of psychological tests for differentiating the higher grades of intelligence. *The score on a psychological test is not a final diagnosis, but a useful variable to use in connection with other facts.* The coefficient (.72) can not be explained entirely by the intrinsic unreliability of the two measures, for both examinations were well built and each involved about three hours mental work. The explanation probably lies, in part, in the attitude of the students to the tests, and in other variables independent of the nature of the tests, although some of the discrepancy is due to intrinsic unreliability of the measures.

If both examinations are made comparable by a method equivalent to the use of standard measures, then, we find that the best measure is the higher of two scores. This is quite in line with our experience in using the tests for guidance of individual students. We do not regard a low score as significant unless supplemented by other evidence. On the other hand, we do regard high scores as significant, on the theory that although a good man may fall down in a psychological test, a poor man will not fall up. We have consistently found the higher of two scores better than the average of two.

A comparison of the coefficients in Table I and Table II shows that scores on psychological tests are just as important variables to use in admission to colleges as the examinations of the College Entrance Examination Board. The correlation between the two types of examinations, *i.e.*, between psychological tests and College Board examinations is about .40, and although we have been trying to break down this correlation for two years, we have been unable to get it lower than .40. If, in the future, we can further refine our tests to reflect native ability more and training less, we may possibly lower this correlation slightly. Research in the direction of breaking up the correlation between the two types of measures is just as important as research toward increasing the predictive value of the two measures, for the goal is final prediction, and the joint yield of the two types depends not only on the high correlation of each with academic success, but also on the low intercorrelation of the disparate measures.

* * * * * * * * *

At Princeton, we have been asked to present data showing correlations of separate examinations of the College Entrance Examination Board with standing in academic courses which depend on preparation in the school subjects which these examinations measure. Such correlations are not comparable with those obtained from single measures, for, if a candidate fails a College Board examination, he may take the paper again, and he does take it until he passes. The college admit-

ting him disregards failures and takes the highest percentage obtained as the significant score.

The weighted average of the College Board examinations of men admitted to the Princeton Freshman class runs uniformly around 72 or 73 with a sigma value around 5 or 6, showing a fair scatter of hits above and below the average, with rare hits below 60—the traditional passing mark. The range of weighted averages is from the low sixties to the low nineties.

The correlation between College Board examinations and marks in academic courses have been figured, using the average of grades in two terms as the measure of academic attainment, and, wherever possible, the average of four terms. By using two terms as the minimum, we overcome some of the difficulties involved in the unreliability of grades—but not all. The data are presented in Tables III, IV, V, VI, and VII.

TABLE III.

CORRELATION OF EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD IN ENGLISH WITH ACADEMIC GRADES IN ENGLISH FOR TWO AND FOUR SEMESTERS.

	Freshman English.		Freshman and Sophomore English.	
	r	*n*	*r*	*n*
Old Plan: Average C.E.E.B. English 1 and 2.....	.30±.03	348	.33±.04	230
New Plan: Mark on C.E.E.B. English Cp. 3.....	.43±.04	121	.42±.07	68

Note: The correlation between the Freshman and Sophomore English courses used here is .62 ± .03 ($n = 311$).

The significant fact shown in these tables is the general low run of coefficients. There is one coefficient of .78 but that was obtained from 31 cases. There is one coefficient of .59, and one of .50, with the rest in the forties and thirties except for scattered instances.

The size of the coefficients of correlation is, among other

TABLE IV.

CORRELATION OF EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD IN FRENCH WITH ACADEMIC GRADES IN FRENCH FOR TWO AND FOUR SEMESTERS.

	Freshman French.		Freshman and Sophomore French.	
	r	n	r	n
Old Plan: Average C.E.E.B. French A and B.....	.50±.03	227	.41±.05	126
New Plan: Mark on C.E.E.B. French Cp. 3.....	.28±.07	84	.08±.11	37

Note: The correlation between the Freshman and Sophomore French courses used here is $.71 \pm .03$ ($n = 100$).

TABLE V.

CORRELATION OF EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD IN LATIN WITH ACADEMIC GRADES IN LATIN FOR TWO AND FOUR SEMESTERS.

	Freshman Latin.		Freshman and Sophomore Latin.	
	r	n	r	n
Old Plan: Average C.E.E.B. Latin 124, 5.....	.35±.10	38	——	—
Average C.E.E.B. Latin 2, 3, 4, 5.....	.59±.03	160	.44±.07	56
New Plan: Mark on C.E.E.B. Latin Cp. 4.....	.46±.07	51	——	—

Note: The correlation between the Freshman and Sophomore Latin courses used here is $.70 \pm .05$ ($n = 54$).

things, a function of the intrinsic unreliability of College Board examinations on the one hand, and of academic grades on the other. We have no data on unreliability of the content examinations, but present in Table VIII the correlations between first and second term grades in the courses used in the construction of Tables III, IV, V, VI, and VII.

TABLE VI.

CORRELATION OF EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD WITH ACADEMIC GRADES IN MATHEMATICS FOR TWO AND FOUR SEMESTERS.

	Freshman Mathematics.		Freshman and Sophomore Mathematics.	
	r	n	r	n
Old Plan: Average C.E.E.B. Mathematics A1, A2, C, D, F	$.33 \pm .05$	163	$.38 \pm .08$	47
New Plan: Mark on C.E.E.B. Mathematics Cp. 4	$.32 \pm .07$	68	——	—

TABLE VII.

MISCELLANEOUS CORRELATIONS BETWEEN EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD AND ACADEMIC COURSES OF TWO SEMESTERS IN LENGTH.

	r	n
C. E. E. B. Chemistry and any Freshman Chemistry course	$.19 \pm .06$	115
C. E. E. B. Physics and any Freshman Physics course	$.44 \pm .06$	89
C. E. E. B. Mathematics (New Plan Cp. 3) and Freshman Mathematics	$.78 \pm .05$	31

TABLE VIII.

"RELIABILITY" OF GRADES IN FRESHMAN COURSES AS DETERMINED BY CORRELATION BETWEEN GRADES GIVEN IN THE FIRST AND SECOND SEMESTERS.

	r	n
English 101a and English 102a	$.57 \pm .02$	470
French 105 and French 106	$.75 \pm .02$	330
Latin 107 and Latin 108	$.64 \pm .03$	268
Mathematics 109 and Mathematics 110	$.67 \pm .02$	260
Chemistry 101 and Chemistry 102	$.68 \pm .03$	184
Chemistry 103 and Chemistry 104	$.75 \pm .03$	90
Physics 101 and Physics 102	$.71 \pm .04$	80
Physics 103 and Physics 104	$.66 \pm .04$	102
Mathematics 101 and Mathematics 102	$.62 \pm .04$	115

Discrepancies between first and second term marks may be due to many things other than the intrinsic unreliability of

the marks themselves, but the coefficients reported give, perhaps, a minimum estimate of the reliability of the grades. The correlation between average standing for the first term and second term in the case of 467 men in the class of 1926 was $.83 \pm .01$. These figures are not conclusive, but are adequate for demonstrating that unreliability of academic marks can not be used as the sole explanation of the low correlations found. The academic grades are based on about a hundred hours of class-room observation and examination—the College Board marks on a relatively few hours of examination.

In one sense, the purpose of College Board examinations is that of predicting academic success, not only in the large, but in specific courses. The coefficients shown in Tables III, IV, V, VI, and VII are difficult to interpret because they are based on one or more examinations, and because the group comes entirely from the passing end of the scale. The true coefficients may be ten or fifteen points higher. One method of judging the meaning of these coefficients is obviously that of correlating the examination with a course it is not intended to predict. We have taken grades in four of the College Board subjects, as follows:

English: Average of English 1 and English 2 weighted 1½ points each and divided by 3.

Latin: Latin 2 weighted ½, Latin 3 weighted 2, Latin 4 weighted ½, Latin 5 weighted 1, and divided by 4.

French: French A weighted 2, French B weighted 1, and divided by 3.

Mathematics: Mathematics A1, A2, and C weighted 1 each, mathematics D and F weighted ½ each, and divided by 4.

The correlation of each of these entrance examinations with Freshman grades in four subjects is given in Table IX. From this table, it is seen that College Board English, Latin and French correlate higher with Freshman English, Latin and French, than with other courses. There is a higher correlation between College Board mathematics and Freshman

Latin than between College Board mathematics and Freshman mathematics—a phenomenon for which the writer offers no explanation. It is interesting to compare the coefficients in

TABLE IX.

CORRELATION OF EXAMINATIONS OF THE COLLEGE ENTRANCE EXAMINATION BOARD IN ENGLISH, LATIN, FRENCH, AND MATHEMATICS WITH ACADEMIC GRADES IN THESE FOUR SUBJECTS.

	Freshman English.		Freshman Latin.		Freshman French.		Freshman Mathematics.	
	r	*n*	*r*	*n*	*r*	*n*	*r*	*n*
C.E.E.B. English.....	.30±.03	348	.22±.04	277	.13±.04	338	.06±.04	227
C.E.E.B. Latin.....	.27±.05	173	.59±.03	160	.30±.06	123	.16±.09	48
C.E.E.B. French.....	.24±.04	314	.28±.04	212	.50±.03	227	.23±.05	182
C.E.E.B. Mathematics.	.16±.05	161	.56±.06	62	.29±.06	121	.33±.05	163

Table IX with those in Table X which were obtained by intercorrelating courses without regard to entrance examinations. The similarities shown in Table X have little correspondence with those found in Table IX. The correlation between mathematics and Latin is the next to the lowest in the table.

TABLE X.

CORRELATIONS OF GRADES IN THE FRESHMAN COURSES IN ENGLISH, LATIN, FRENCH AND MATHEMATICS USED IN TABLE IX.

	English 101-2*a*.		Latin 107-8.		French 105-6.		Mathematics 109-10.	
	r	*n*	*r*	*n*	*r*	*n*	*r*	*n*
English 101-2*a*.....	——	—	.53±.03	287	.54±.03	193	.29±.05	190
Latin 107-8.....	.53±.03	287	——	—	.68±.03	140	.38±.08	60
French 105-6.....	.54±.03	193	.68±.03	140	——	—	.59±.07	44
Mathematics 109-10...	.29±.05	190	.38±.08	60	.59±.07	44	——	—

In spite of these apparent difficulties of interpretation, Table IX shows a fact of considerable importance, namely, that all four measures correlate to some extent with academic

standing in courses not ordinarily considered as related. If, therefore, the purpose of the examinations is to predict performance in a certain course, that prediction can best be built up by combining several measures, rather than by relying on one measure entirely. Stated differently, it would seem that an apparent failure in a specific paper may be entirely compensated by successes in other papers—a fact which is ignored in the rigorous application of the unit system whereby a man is accepted if he passes all 15 units and rejected if he fails one or more specific papers.

* * * * * * * * *

The statistical treatment of the data in the preceding pages will strike the experienced statistician as haphazard and offhand. The data apparently demand a certain stereotyped form of treatment, which would take into consideration the correlation of each of the variables with the criteria chosen, and the intercorrelations of these variables. Such data are not available. If a candidate is allowed a considerable amount of latitude in choosing the subjects he offers for admission, and latitude in his electives after admission, one can not find cases who have taken the same papers for entrance and the same courses in college. Exact matching of candidates in this respect gives populations too small to treat. Attempts to widen the study by including several colleges would lead to the problem of equating term grades from colleges to college—which is a greater evil. The writer has merely taken all the data available, and presents them for what they are worth. He realizes the inadequacies of the treatment, and admits that "conclusions" can not be drawn from the data in the conventional one, two, three order. On the other hand, it is a matter of public scandal that academic legislatures have, in the past, paid little attention to empirical data, and have enacted rules and regulations for college entrance which assume *unit* correlations between the measuring instrument and the thing it is supposed to measure.

None of the data presented here is cited in any spirit of

criticism of the College Entrance Examination Board. That board is a cooperative body, and is just what its members—representatives from the various colleges and preparatory schools—make it. But the data may be used quite justly to criticize the employment made of these examination marks by some of the colleges.

If a man fails all of his College Board examinations, there is little doubt as to his unfitness. If he passes all examinations with an average of 80, there is little doubt as to his fitness. But, no scale of marks can be used as a just basis of prediction in border-line cases unless it correlates considerably higher with the thing it is supposed to predict than these examinations do. The exact area of the border-line zone can not be determined from our data, but from the general run of coefficients reported, it is apparent that it is larger than is ordinarily believed.

A candidate for Princeton was denied admission in 1923 on the following record of College Board examinations:

	Per cent.
Latin 124 (3 units)	79
Latin 5 (1 unit)	55
Spanish A (2 units)	62
Spanish B (1 unit)	62
English 1 (1½ units)	66
English 2 (1½ units)	57
Mathematics A (1 unit)	62
Mathematics A2 (1 unit)	62
Mathematics C (1 unit)	62
Chemistry (1 unit)	62
American History (1 unit)	70

The failures were in two examinations, Latin 5 and English 2, the passing mark being 60 per cent., and the grades secured 55 per cent. and 57 per cent. respectively. One year later, he passed these two remaining examinations with a grade of 78 per cent. in each. We gave him two intelligence tests showing him exactly at the average of our admitted population, the average being 51 and his two scores 49 and 52. As far as the failure in Latin 5 (Virgil and sight translation of po-

etry) is concerned, some of the prediction of ability in Latin is carried by Latin 124 (Latin grammar, composition and Cicero), and, by inference from Table IX, by English, French and even mathematics. Similarly, the prediction of success in English is carried to some extent by English 1, and also by other subjects. If the correlations of averages of examinations with subsequent attainments do not constitute an adequate basis of prediction, obviously specific papers, with their element of unreliability, are even less certain. If this man was a fit case for admission in 1924, he was probably as fit in 1923. It is not fair to his family to support him for another year in a secondary school, and not fair to the boy or society further to postpone his admission to college.

Many people will object to the interpretation of this case, insisting that the differences between 55 per cent. and 78 per cent., and 57 per cent. and 78 per cent. represent real improvement, and that the additional year in school was worth while. That may or may not be true in this particular case, but, by and large, there is no evidence to show that the examination system is sufficiently accurate to justify exclusion in cases of this sort. If entrance examinations would correlate as highly with college standing as .85 or .90, then colleges might be more confident in the rigorous fixing of standards. But colleges are not warranted in *assuming* these high correlations, since the evidence shows that they do not exist. The correlations obtained are more frequently in the .50 to .60 range with a few institutions getting as high as .75. In view of this fact, the youth of the land have some *rights* in the matter.

Our elementary school system, as organized, places the superior child under a sufficiently heavy handicap. All children who can complete the first eight grades in six years are not permitted to do so. And, again, in secondary schools, a youth who could finish the four years in three rarely has the opportunity. It is not maintained that acceleration should be forced, but merely that the system has the effect of retarding the able youth. Colleges, by erecting elaborate systems of

entrance requirements, are further delaying the normal progress of these individuals. The writer is not urging that colleges lower their standards, but that they study their own entrance systems, discover their shortcomings, and apply only such rules and regulations as are empirically warranted.

The injustice in the present system of admission to many colleges comes from the rigorous use of passing marks and credit units. Marks obtained in College Board examinations should be treated as any other system of educational measurement—with suspicion in the first instance, and directly proportional to their demonstrable predictive value in the second instance.

The present situation would seem, however, to demand something more than the attitude of honest skepticism, and, most fortunately, two movements have started which should improve affairs. In the first place, a Commission of the College Board appointed to study the "New Types of Examinations" finds "The claims for the new type examinations have in the judgment of this Commission been so far substantiated as to make it seem desirable for the College Entrance Examination Board to consider carefully whether it shall not endeavor to incorporate in its own examinations at least some of the features which the new type examinations present" (p. 19 of report of the Board, dated September 1924). The "new type" examinations referred to are those which are constructed from the true-false, yes or no, recognition, or completion forms of questions, covering a very wide range of subject-matter, and being scored objectively.* These new type examinations should not be confused with the "New Plan" or system of comprehensive examinations. The evidence assembled indicates that examinations consisting in part of the new type of content examination, and in part of the essay type of question will give more consistent (reliable) measures of the candidate's knowledge of the subject matter, and that this combined examination will correlate higher with

* A discussion of this form of examination may be found in Ben D. Wood's "Measurement in Higher Education," Yonkers, 1923, pp. 337.

subsequent academic attainment than the ten-question, essay type of examination alone.

In the second place, the College Entrance Examination Board, at its annual meeting in April, 1925, took definite steps toward the giving of psychological tests in connection with the examinations of candidates for admission to colleges and universities. The evidence assembled on this point shows that such tests will supplement the Board examinations very strongly. The content examinations of the Board when placed in team with good psychological tests should give about the best prediction we are able to get to-day. The use of psychological tests is fraught with many dangers, especially from their overuse or abuse, but properly treated and interpreted, these tests are extremely valuable, not only for entrance, but also for advice after entrance.

The writer wishes to emphasize the need for regarding the problem of college admission as an experimental or empirical problem. At present, the technical questions of college admission are in the hands of academic legislatures. This insures a certain conservatism in the changing of methods, but this may be tantamount to the preservation of obvious malpractices, if legislative enactments are made without regard to actual findings. The writer ventures to suggest that the sounder practice would be that of experimenting with different types of measures. If necessary, a college may devote the entire first week of the Freshman year to the business of trying out various types of measuring instruments. The results of these examinations may then be filed away, and studied after the academic careers of the men examined are known. In this way, the college may try out various methods of entrance on paper, without altering their existing methods, and may improve those methods by such additional devices as the evidence warrants. There is obviously room for improvement.

FUEL ENGINEERING.

C. M. YOUNG

Professor of Mining Engineering, University of Kansas.

It is a fact, whether fortunate or not, that education in what has been called mining engineering in this country has been concerned principally with the metals. Some instruction has been given in coal mining and some attempts are now being made to enter the field of petroleum and gas production, but the great bulk of graduates in mining engineering have been drilled more especially for the production of metals. Until recent years engineers so trained have dominated the engineering societies, but the increasing prominence in the A. I. M. E. of men interested in the mineral fields has been very noticeable, and is indicative of the growth in numbers of men so interested and of improvement in quality as well.

The fuel industries are very young and they have grown to enormous size without any adequate direction, yet the production of mineral fuels had attained such tremendous importance in our time and the increase of the utilization of such fuels is so rapid that the necessities of engineering in connection with them are demanding an education which has been somewhat reluctantly given. It might be added that the producers of the mineral fuels, by which I mean those who provide the capital and plan the general operation, have been loathe to recognize the importance of engineering in their fields. I do not believe that this argues that lack of engineering is responsible for the present chaos in the coal industry but surely application of engineering ideas would have obviated a large part of the confusion which reigns therein.

The needs of the fuel industries for engineering work, in spite of the fact that those needs are somewhat tardy of rec-

ognition, are so great that it may be that the time has come for the offering of something more than a few courses of study in coal mining and oil and gas production and for the development of whole curricula devoted to specialized training in the fuel industries. For this reason, I have given some thought to a division of what for the present may be called mining engineering into two principal branches, not metals and non-metals, but fuels and non-fuels.

It is evident that there are very great differences, both physical and economical, between these two branches of mineral production, differences so great as to thoroughly warrant this distinction. Among these are differences in specific gravity; in value per ton; in physical form of deposits; in processes of concentration or cleaning; in place of origin; in the character of labor employed; in the organization of mine labor; in the methods of payment; in the hazards encountered; in possibility of storage; and in markets.

These differences and the great and increasing importance of the mineral fuels suggest the establishment of training in what I will call fuel engineering. This is a very broad term and can include production and utilization of all mineral fuels. This would not be new in all subjects covered, for much of what is desirable is covered in one way or another in existing schools, but in the importance given to it in the planning of curricula and in the recognition of the desirability of careers as engineers in connection with fuel production and utilization.

The necessity for engineering in coal production has long been recognized by some but unfortunately this recognition has not been as wide as it should be and the engineer has never attained such prominence in the councils of the industry as is justified by the importance of his work. Coal mining is a vastly overdeveloped industry and the next few years are sure to see an intense struggle for survival. It is not to be thought that a people of average intelligence will long tolerate a condition in which so much more capital

and so many more men are employed than are necessary to obtain the output desired. Before long we are sure to realize what has been so often and so widely proclaimed, that this condition of necessity constitutes a severe burden in cost of fuel. The greater the cost of fuel the less development there will be of mechanical engineering, the less improvement in our standard of living. Since it is not to be thought that this congestion of capital and man power can continue indefinitely it must follow that only those enterprises which are most economically conducted can expect to survive and I think we shall find that only those can be most economically conducted which are managed by the most highly trained men of intelligence. Therefore I believe that coal mining in the future offers a most attractive field for mining engineers.

But I would consider in connection with coal a wider field than mere production and include preparation and utilization: It is true that much coal can be used in the raw state but it is also true that no one has ever tried to find out how much benefit will accrue from the treatment of a great deal of coal which is now used raw.

There is another phase of the subject of coal utilization which offers opportunity for expert treatment, namely the adaptation of fuel to situations, perhaps I might say the prescription of fuel for any given use. At the present time the selection of fuel is largely a matter of habit, influenced of course by price. It should be possible, assuming proper control of the machinery of production and distribution, to select for many given cases the most economical fuel. Doubtless in some cases the best results would be obtained by the blending of fuels. Though this prediction seems visionary to those who see only the present condition of the coal industry, I think it is not unreasonable to expect that the future will see such prescription of fuels and such blending of fuels where at the present time little is attempted beyond the adaptation of methods of burning to the fuels at hand.

Attention to the combustion of the solid fuels of course in-

volves consideration of partial combustion with recovery of by-products so that the chemistry of coal would include destructive distillation and a branch of this course of fuel engineering would be devoted to coal combustion and to distillation. Though this latter subject has received the attention of some very able men I believe that its possibilities are not appreciated.

Of course there would be included in this field of fuel engineering a study of the liquid and gaseous fuels. At the present time geology has made itself felt in the petroleum industry and the larger producers base their operations on the findings of staffs of geologists. However, there is too little engineering in the petroleum industry, too much waste and too much scattering of resources. The petroleum engineer should not be trained to locate oil pools or the possibility of them, which is the work of the petroleum geologist, but to interpret underground conditions and to handle the resources of the discovered pools so as to draw from them the highest possible returns.

Petroleum distillation has become a well recognized branch of chemistry. It would naturally be included but does not require the emphasis on its importance which is needed for some of the other suggestions made.

The future large utilization of oil shale seems a certainty and the engineering problems of handling it and the chemical problems of treating it should receive very full attention.

It is evident that some of the subjects mentioned are already treated as branches of mechanical engineering and chemistry. I do not underestimate the progress already made, but emphasize the desirability of a view of the whole field. The mechanical engineer may be well trained in the utilization of coal in the boiler room, but the mechanical engineer who knows how to get the coal which will give the lowest cost of power is rare, and I believe that it is possible by proper training to develop an engineer who will know how to prescribe the coal best suited to a given set of conditions, leav-

ing to others if necessary, the planning of engines, dynamos, steam lines, etc. In other words it may be desirable to develop a cleavage in the field of mechanical engineering, leavin one side the development of energy in the form of heat and perhaps in the form of steam, or perhaps again the development of energy in the form of combustible gases; and on the other side, the transformation of that energy into mechanical energy, electricity, etc.

There should be included a study of economics and of sociology. It is evident that the mineral fuels have a great public importance and that large numbers of men will be employed in producing and utilizing them. The numerous problems of economic and sociologic nature encountered should be attacked by men trained in the humanities as well as in science and engineering.

I am suggesting then the establishment of varied curricula designed to prepare men for the best handling of the mineral fuels. In these the geology would be that of coal, oil and gas, and not of ore deposits, the chemistry would be that of coal and oil, and of combustion, the engineering and design addressed to the problems proper to the fuel industries. We should be consciously and purposefully training men for the production and use of the mineral fuels, on the use of which is based that great employment of mechanical power which distinguishes the present age and which promises to increase.

THE VALUE OF PROBLEMS IN TEACHING METALLURGY.

BY CLARK B. CARPENTER,

Associate Professor of Metallurgy, Colorado School of Mines.

The great value of problems for illustration purposes and for driving home the salient facts of technical practice and theory, was, we believe, brought home to us in two undergraduate courses at the University of Kansas; one, Calculus 2, a course in Integrations and Differential Equations, under Dr. Charles Hamilton Ashton, and the other Chemistry 3, a course in Qualitative Analysis, under Dr. Hamilton Perkins Cady. These courses were taken at the University during the academic year 1909–1910 yet twelve years later the essential basic principles of integrations and differential equations and likewise the calculations involved in the problems given in qualitative analysis aided us in attacking more or less successfully the problems in thermochemistry and chemical equilibrium which one must needs know before he can reasonably and successfully teach modern metallurgical subjects.

The metallurgy of iron and steel offers a most wonderful opportunity for the presentation of theory by means of problems. At Colorado School of Mines the course in this subject has been rearranged to permit the use of one period in each week to problems dealing specifically with the subject of iron and steel but which may be applied to other branches of metallurgical science. In this course the opportunity is offered of presenting to the student problems dealing with the laws of thermochemistry as exemplified by problems dealing with thermochemical equations, thermochemical measurements, the law of Lavoisier and Laplace, Hess's law of Constant Heat

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Summation, the heat involved in gaseous reactions which take place at constant pressure in contrast with those that take place at constant volume, the heat capacities of gases and of solids, and many other items essential to an understanding of metallurgical processes which time does not permit mentioning.

Thermochemical equations can be used to advantage in illustrating the heat involved in burning of coke in the blast furnace; by the burning of blast furnace gas in the hot stove, in reheating furnaces, and under boilers; by the combustion of producer gas in the open hearth furnace. An extremely interesting series of reactions making use of thermochemistry is the operation of the bessemer converter and the heat balance of this operation is probably of greater value in clearly establishing the mechanism of the reactions and in showing why it can and does take place than hours devoted to a lecture concerning the same process.

The law of Lavoisier and Laplace (1780), more clearly stated by Mayer (1842), is involved in the decomposition of the limestone in the blast furnace, the open hearth, and in the electric furnace. It is well to point out not only that the stone must be decomposed before a slag can be formed but it is also necessary to illustrate by a problem the quantity of heat involved in the decomposition reactions which take place.

Another series of reactions which take place in the blast furnace and which are closely related to a decomposition reaction yet are in fact oxidation and reduction reactions, are those reactions involved in the change of the iron oxides from the oxide form to that of pig form. There are three possible combinations in which these reactions may take place and the heat involved is different in each case. Heat economy is of great importance in blast furnace operation. The reactions mentioned may take place with the liberation of heat or they may take place with the absorption of heat. Gruner contends that the reduction of the oxides is by means of carbon monoxide, or indirectly, and that this is the most economical method. Why this method of reduction is more economical than by a direct reduction with carbon can only be shown

to a class by means of problems in thermochemistry, and it is a very pretty problem to assign to a class to calculate the net heat gained when the reaction takes place indirectly rather than by direct reduction. Of course we now know that the most economical condition is when most of the oxide is reduced indirectly and the remainder directly, but this can be shown mathematically if the weights of fuel entering the furnace, the burden over a period of time, and the analysis of the furnace products are known.

The law of Hess dealing with Constant Heat Summation seems to us to be applicable not only in the burning of blast furnace gases in the hot stove in which the temperature of gas prior to combustion is constantly undergoing a change in temperature involving a constant change in the heat evolved by the combustion of the carbon monoxide, the hydrogen, and any other combustible substances which the gas may contain, but also in the combustion of producer gas in the open hearth furnace. Of the two the combustion of the producer gas is undoubtedly the better illustration of Hess's law because in this case the temperature of the reacting gases is already at a high temperature giving a value for the heat evolved on combustion that shows a decided contrast with the heat evolved at 20 degrees under constant pressure conditions. Here again we maintain that a problem illustrating the point is extremely valuable in driving home the facts involved.

The heat capacity of gases is a problem with which practically all branches of metallurgy deals. Problems dealing with this phase of metallurgical operation revealed to a class the fact that the products of combustion from a hot stove carried away over 20 per cent. of the heat exolved in the burning of the blast furnace gas in the stove, while in the case of an open hearth furnace the total heat in the gases escaping from the furnace was over 68 per cent. of the total heat involved in the furnace reactions, while 93 per cent. of this heat in the escaping gases was the result of the heat capacity of the gases themselves, and only 7 per cent. of the heat in the escaping gases could be attributed to unconsumed

carbon monoxide. Curiously enough the heat capacity of gases is generally considered to be a straight line function, an assumption that is absolutely erroneous. The fact is that the heat capacity of a gas increases not only with the temperature but also with the complexity of the gas so that to teach a student that the heat capacity under constant pressure or under constant volume conditions is a constant is incorrect. In problems which deal with heat capacities the values expressing the molecular heat capacities selected by Lewis and Randall * are probably as reliable and as trustworthy as can be obtained. These values are empirical; the mathematics involved is simple; the quantities involved are molecular weights or volumes. We personally prefer to use volumes rather than weights because the gases are measured by volume in actual metallurgical operations. What has been said about the heat capacities of gases applies with equal force to solids except that in the case of solids one must generally deal with substances that undergo polymorphic changes involving heat. Never the less there is no need denying the fact that the heat capacity of solids is likewise not a straight line function but is rather something that changes with the temperature and the modification of the metal with which we are dealing.

The principles involved in chemical equilibrium in metallurgical operations can be illustrated by the use of problems. The dissociation of limestone as affected by temperature and by the partial pressure of the carbon dioxide; the system iron oxide, iron, carbon monoxide; also that of carbon, carbon monoxide, carbon dioxide. Oxidation and reduction reactions, roasting reactions, and many other reactions which take place in metallurgical operations undoubtedly can be explained to better advantage by means of problems than by long drawn out discussions involving many theories which may or may not fit the facts.

What has been said concerning iron and steel applies in part at least to the metallurgy of copper, of zinc, and of other metals. There is nothing mysterious in the reactions

* *Journal American Chemical Society*, No. 34, 1128, 1912.

which take place in the reverberatory furnace in copper smelting but in the converter operation the problem is quite different. The operation of the converter in copper smelting offers a splendid opportunity to drive home the fact that the heat involved in the reactions is supplied by the reactions themselves, that it is the oxidation of ferrous sulphide to ferrous oxide and sulphur dioxide and sulphur trioxide, and the formation of a ferrous silicate slag that furnishes the net heat required to keep the contents of the converter hot and allow the reactions to take place. In this instance almost every reaction that takes place is a heat evolving reaction but what are the conditions during the blowing of the white metal into converter copper. There are two series of reactions taking place simultaneously in the converter during this part of the process one reaction absorbing heat and if it only took place the contents of the converter would soon freeze. However the contents do not freeze, in fact cold material can be added to the converter and yet not materially stop the process. If this is the case then the second reaction must evolve heat insufficient to supply the deficit resulting from the first reaction and in addition furnish the necessary excess heat. It is just as easy to show by means of problems that cuprous sulphide reacts with oxygen to form cuprous oxide and oxides of sulphur with evolution of heat and that the cuprous oxide and cuprous sulphide react to form copper and oxides of sulphur with absorption of heat as it is to spend half an hour smothering the student with a wordy explanation of the reactions involved and the results obtained. The solution of the thermochemistry involved will be absolutely conclusive and furthermore it can be seen.

In the case of the pyro-metallurgy of zinc there is the reduction of zinc oxide by carbon producing metallic zinc vapor and carbon monoxide. Heat is evolved by the combustion of carbon to the monoxide and by the liquifaction of the zinc vapor to metallic liquid zinc. The question is, is the heat evolved in these reactions necessary to keep the temperature of the substances involved at the reacting temperature and

supply them with the heat necessary for the reactions to take place. A small problem in thermochemistry will quickly show that there is a deficit which must be supplied from an outside source. We have heard of an instructor in metallurgy who did not know the source of the excess heat necessary to keep the reactions going. Apparently he had not tried to solve the problem by using a few simple mathematical equations involving the heats of reaction of the substance involved. We maintain that had he been able to illustrate the point at hand mathematically his class would have had a better and more thorough understanding of the subject than would be the case if simply told that outside fuel supplies the excess heat necessary.

Problems as useful vehicles to explain certain phases of metallurgy can be applied to hydrometallurgy as well as to pyrometallurgy. The solution of zinc calcines by sulphuric acid or by an ammoniacal leach solution is a reaction involving energy the same as any other reaction. The same statement applies to the leaching of copper, of gold and silver, and of lead. Personally we have nothing to do with the general metallurgy of the nonferrous metals but we feel that the opportunity is present for the development of the problem side of the subject along the lines of heats of solutions and heats of ionization, to bring before the student the facts involved.

The field of electrometallurgy involves calculations somewhat different from those met with in pyrometallurgical practice yet the rapid advance in electrometallurgical practice has created a need for problems dealing with the use of electricity in smelting operations, in the precipitation of metals from solution, and in the heat treatment of metals. In general for the use of the student who is not specializing in electro-metallurgical work it is probably not advisable to develop the use of problems beyond calculations involving current density, current efficiency, transport numbers, and heat generated.

Personally, we do not believe there is a text on the market, either for class room or for reference, that meets the needs of problem courses or for general problem work in metallurgy.

Richard's "Metallurgical Calculations" contains an enormous amount of data, some good, some bad, but the assumptions made do not seem in some cases to be at all justified and in many instances the constants chosen can hardly be accounted for. One who would use this book for a text would do well to rework every problem whereupon he will find many errors in calculation. It is nevertheless a wonderful work, and one for which full credit should be, and we believe has been given.

In closing we wish to state a second time that in our opinion it is impossible to teach metallurgical subjects without using many problems illustrating the facts, the theories, and the reactions involved. Physical chemistry, physics, electrochemistry, thermodynamics, calculus, all have to be and should be used. The day of the rule of thumb is gone and metallurgical science is becoming more and more exacting in its demands. The result is that teachers of metallurgy must be more exacting in the presentation of the subject and one solution that appears to us, is, to make every possible application of mathematics, use problems, to assemble the known facts with figures.

Type Problems.

1. The volume of a gram mole of oxygen at 0 and 760 is 22.4 liters. What is the volume of a pound mole of oxygen in cubic feet under the same conditions of temperature and pressure.

2. Carbon plus oxygen equals carbon dioxide plus 97,200 lb. cal. 2 carbon plus oxygen equals 2 carbon monoxide plus 2 x 20,160. Required the heat evolved per cubic foot when carbon monoxide burns to carbon dioxide.

3. A blast furnace gas has the following analysis:

Carbon dioxide	13.06
Carbon monoxide	25.78
Hydrogen	3.69
Nitrogen	57.47
Total	100.00

The gas is burned in a hot stove, giving as products of combustion carbon dioxide, water gas, and nitrogen. Required the heat evolved per cubic foot of gas burned.

4. In a test on a 2-pass central combustion hot stove at the Duquesne plant of the Carnegie Steel Company the volume of gas burned per minute was 6,000 cubic feet at 62° F. The temperature of the flue gas from the hot stove was 612° F. The blast furnace gas burned had the following composition:

CO_2	13.06	H_2	3.69
CO	25.78	N_2	57.47

The stove was on blast furnace gas for 198.75 minutes. The flue gas analyzed CO_2, 21.30; O_2, 2.90; CO, 0.80; N_2, 75.00. The stove was on blast 64 minutes. The volume of air at 62° F. was 40,580 cubic feet per minute. Temperature of emerging blast from stove was 1076° F. Required: Heat loss in flue gas; heat loss in unconsumed CO; heat absorbed by air blast.

5. For the year ending April 1, 1919, the average temperature of the blast entering furnace No. 3, Inland Steel Company, was 1002° F. The volume of air entering the hot stove per minute was 44,190 cubic feet at an average temperature of 60°F. What quantity of heat per day was carried into the blast furnace by the blast, and how much coke, 90 per cent. fixed carbon, burning at 20° C. would be required to furnish this quantity of heat. Assume that the blast entering the furnace is dry. Specific heat of N and O:

$$\frac{dQ}{dT} \text{ equals } 6.5 \text{ plus } 0.0010\ T.$$

6. A gross ton of coal having the following analysis was burned in a gas producer:

H	5.02	C	76.23
N	1.38	Ash	5.65
O	10.61	Moist	1.11
B. T. U.			14,310 per pound.

The ash from the producer analyzed: C, 4.90; in comb, 95.1
The producer gas had the following analysis:

CO	27.3	H_2	14.3
CH_2	3.0	Co_2	0
C_2H_4	0.4	N_2	51.0

Required: Calorific value of the gas per cubic foot; cubic feet of gas per pound of coal; efficiency of the producer.

7. The analysis of the gas entering the ports of an open hearth furnace is:

CO_2	10.0	CH_4	2.6
CO	15.6	N_2	59.8
H_2	12.0		

The products of combustion have on analysis:

CO_2	13.0	CO	1.4
O_2	4.4	N_2	81.2

The gas entering the ports was 33,710 cubic feet, and air 42,138 cubic feet per ton of steel produced (standard conditions). The gas entered the regenerators at a temperature of 600° C. and the furnace at 1075° C. The air entered the regenerator at 20° C. and the furnace at 1100° C.
Required: Sensible heat carried into the furnace by the gases; the heat of combustion of carbon monoxide to carbon dioxide, and of methane to carbon dioxide and water as gas at the temperature at which the gas enteres the furnace, if the heat of combustion of CO at 20 is 189 calories, and CH_4 is 531.8 calories per cubic foot; the sensible heat carried out of the furnace by the products of combustion if they leave the furnace at a temperature of 1560° C.; the potential heat carried out of the furnace in the unconsumed CO.

DISCUSSION.

F. A. Thomson: I think Professor Carpenter is to be congratulated on this paper, and I think also that there is no question in the world but that the problem method of teaching anything is preferable to the "conversation method" of teaching it. Old Doctor Raymond, the veteran and long-deceased secretary of our Institute, said in an editorial shortly before his death that the kind of thing which Professor Carpenter has been talking about elicits quantitative thinking as contrasted with qualitative thinking; and I think that is the essential basis of the argument for Professor Carpenter's method. I am sure that all of us use that type of method to a greater or less extent. I used a copy of our worthy chairman's text on "Principles of Metallurgy" when I was teaching the course in general metallurgy, with problems on combustion, and other similar problems, involving the thermal capacity of gases, and other matters of that sort of which Professor Carpenter has spoken; and I cannot believe that anyone will not agree—I hope there is someone—that the problem method of teaching anything is the way of teaching, because by this means you can get a student to focus his knowledge—or ignorance for that matter—at the point of a pencil, and start to working a problem, and if he does not know his "stuff" he cannot work the problems. We are all familiar with the brilliant, superficial young man, who slides along very nicely in this course and that course, but who says, "Professor," or "Dean," or "President," "I can't just get mathematics." We know what is the matter with that fellow. Pretty nearly always he is trying to get by on his "face" and his personality, and he is not willing to concentrate his gray matter down at the point of his pen or pencil, and get right in and dig and work; and the problem method, whether it be in mathematics or any other subject, is the thing which brings that out, absolutely.

There is just one very minor point that I want to touch upon. Professor Carpenter says that in his thermal capacity problems he rather prefers volume to weight. I think the

volume calculations are perhaps a bit simpler than the weight calculations, but I think it is well worth while for the metallurgical student to deal also with the weight of the gases passing into and out of a furnace. I have never had a student who was not astounded to find the number of tons of nitrogen that is discharged in a given time from any metallurgical furnace. The gas is invisible, and volumes, after all, do not mean very much to the average student; but tons weight is something that he is more familiar with and he gains a better conception of the enormous quantities of gases involved, if he deals in weights rather than with volumes.

I was glad that Professor Carpenter referred to Professor Richard's text on "Metallurgical Calculations," which is a monumental work. There are some errors in it, of course. I remember the work of another author who has since passed to his reward, but whose text contained some calculations on the formation heats of slags. I labored through this problem night after night, and the further I got the worse the problem seemed. Finally I wrote to him and I said, "This is the way it appears to me; I cannot reconcile it with your problem. What is your opinion in the matter?" And he came back in a very courteous letter, I recall, and with a long explanation in which he made the comment, "I hope this explanation is quite satisfactory to you, but I must admit it is not satisfactory to me." (Laughter.) I hope Professor Carpenter and the other teachers of metallurgy will keep on going, sticking to and emphasizing more and more the problem method, because there is no doubt in the world that it is the proper way of teaching. I would like to hear someone at some later time discuss a similar situation with respect to the teaching of mining methods. It is one of the most elusive things in the world, because it is almost impossible to reduce it to the problem method of handling.

Professor Carpenter: We do teach the use of weights of gases.

PERSONNEL WORK IN THE COLLEGES.

BY W. J. CREAMER, JR.,

Assistant to the Dean, College of Technology, University of Maine.

Personnel work is not new in the industries, but the establishment of a college department for the express purpose of studying and developing the personality of the college student is a comparatively new departure in educational work, undertaken up to this time with any degree of thoroughness by only a very few institutions.

It may be suggested that each instructor in a college or university is a personnel officer, who by careful observation of his students should be able to combat their weaknesses, and should be able to determine and develop their special capabilities, thus helping to direct them toward their properly high station in our social system. But a little consideration of this rather stupendous problem will soon convince the investigator that to demand such an analysis by the instructor is manifestly unfair. Overburdened as most college instructors are with a large number of classes, or classes with a large enrollment, or both, there is little opportunity for the study of the individual student. Certain ground in the texts must be covered, or certain lecture material must be presented, in all too short a time to allow of any extended analysis of the personality of the individuals in the class. The college class of to-day is a mass meeting, in which the individual is swallowed up by the system. If he proves to be indigestible, the system promptly rejects him; if he is more or less digestible, the system passes him on. It is of course true that the really capable instructor can in two months' classroom observation learn a great deal about some of his students who possess outstanding characteristics, either good or bad; but his opinion, we must remember, is usually based upon their performance in one particular course of study, in which their ability and interest

may be markedly different from their ability and interest in other subjects. The instructor's opinion, though possibly correct, is based on insufficient evidence, and colored by first impressions and items of class-room behavior, which are far from being indicative of the real worth of the student under observation.

But we must consider the attitude of the employers of the graduates of our higher institutions. Of late years the tendency of the industries has been to demand the *man* rather than the *student*. By this I do not mean that the good student is not wanted; he is, and badly; but I do mean that employers think more of a man's common sense, his breadth of interests, his personal manner, his character, than they do of whether his mathematics grade is 85 or 95 per cent. Employers want not so much a mind trained in a special field, as they do a trained mind simply, a mind which can function in various channels at the bidding of the possessor, applying its trained faculties to the solution of problems of diverse nature, correlating information in widely differing fields, it may be, to attain a given end. Even in the highly specialized field of engineering, the large employing companies are not expecting or desiring the colleges to give their students an intensive specialized training. They expect and desire rather that the colleges shall drive home certain fundamental laws and principles; that they shall train the mind to become active, capable of inductive and deductive processes, rather than to serve merely as a passive storehouse of facts; that they shall develop those qualities of character such as sterling integrity, reliability, tolerance, tenacity of purpose, which are the prerequisites of real success; and that they give to their students the open sesame to the cultural side of life, without which any man becomes an unseeing, unhearing machine, rather than a rational being, vibrant to the beauties of all life and art.

And the student himself—to what does his expenditure of time and money entitle him? Does it entitle him merely to a seat in a classroom where information may be thrown at him, which may or may not reach the mark, where his individual

mind may be trained only in so far as it will respond to the type of instruction used for the mass; or does it entitle him to something more? Perhaps it really entitles him, not only to this, but also to a careful analysis of his successes and failures, of his mental capabilities and disabilities. If he has entered college with insufficient preparation, or with a mind as yet immature, it entitles him to be told so frankly and to be dropped from the college rolls, without disgrace and with the understanding that he will again be given trial when his preparation is more complete and his mind more mature. If he has difficulty with his chosen major subject, it entitles him to a careful analysis of that difficulty, with the view of removing it or directing him toward another field of endeavor which a little study will often show to be more suitable for his type of mind. If he develops interest in subjects outside the boundaries of his chosen curriculum, he should be encouraged. Breadth of mind was never in disrepute. The science major with a little of the arts, the arts major with a little of science, are both better citizens for being thus broadminded.

To sum the matter up, then, it appears that industry has outdistanced the college. While the industries are taking all possible pains to sort out their human material to their own advantage and the advantage of the individuals themselves, the colleges have complacently drifted along, assuming on account of the popularity of a college education that they are functioning in the best possible manner, whereas actually their educational efficiency in producing superior citizens is woefully low. According to L. L. Thurstone, of 490 students who registered as Freshmen at Carnegie Institute of Technology in 1919 only 26 per cent. remained in college after 22 months. This is typical of what goes on in every college. The mortality rate is too high. Too much time is wasted on men who fail to complete their courses. This one item of educational waste is enormous. The situation is analagous to the problem of labor turnover in the industries. It is certain that many of these who go down in the struggle should be eliminated long before they are, in justice to themselves

and to their more fortunate fellow students. There is such a thing certainly as a college education being bad for a man. It is certain, too, that many of those who fall out of the ranks are unjustly penalized simply because they have chosen the wrong company and cannot avail themselves of proper counsel and encouragement.

But what are we doing about this situation? We have, indeed, our conscientious instructors and professors, our department heads, our deans, and our committees on administration, all exercising to a degree the functions of the personnel officer, the teacher, and the disciplinarian. No division of labor here, certainly, but plenty of division of the laborer. Such a system not only does not make for coördination but rather for aimless and ineffectual effort.

We have, too, our psychological tests, which are supposed to give an index of the student's abilities, but these tests are still in the experimental stage, and experience has shown that in many cases they do not measure with sufficient accuracy the qualities which they profess to measure. Correlation studies have been made, showing the effect of high-school training, age, intelligence quotient as determined by psychological tests, and various other variables on college achievement; and some very interesting results have been obtained in the average. But the point to be made is this: that the relations hold good only in the average. The variation of the individual from the average is enormous; and it is here that the personnel officer must take up the problem where the statistician is forced to drop it. True it is that the personnel officer can make use of statistical methods, but he must never forget the individual. His concern primarily is with the individual; and his problem is not to fuse him with the mass average, but rather to separate him from the mass, and to find out why he differs from the average. If this deviation from the average is in the wrong direction, treatment must be prescribed to develop to the utmost the outstanding ability rather than to confine it to the mediocre limits of the mass average. But it is a deplorable fact that this highly interest-

ing and important study of the individuality of the highest types of young men and women to-day is not being made in any systematic manner.

But the adverse critic should have a specific or at the least some nostrum for the malady he has diagnosed. I shall therefore prescribe for the case with complete disregard of the possibility of the reader's carrying my figure a little further and shouting back at me: "Quack! Quack!"

I am proposing the establishment of a Department or Bureau of Personnel in every college and university, and the redistribution of responsibility. Instructors and professors should be occupied with teaching duties and not with a thousand and one other things, including attendance at faculty meetings where a multitude of petty questions, which would be dismissed by a single efficient executive in a minute's time, are discussed *ad nauseam* in all their minute ramifications.

It goes without saying that the president, the deans, and the registrar should be included in the membership of this department, but they should not be required to devote a large amount of time to its work. The real work of the department could be handled, with sufficient clerical assistance, by one executive to five hundred students. The members of this department should certainly have had teaching experience but should not be required to teach while carrying on these duties.

The power of this department would be great. First of all it would take over the duties of a host of committees, the membership of which is now made up from the teaching staff. It would also relieve the deans and the president of much petty administrative work, and thus allow them more time for questions of general policy, and supervision of curricula and the educational methods of their teaching force. By a study of the accomplishments of the students, it could prescribe rational entrance conditions and keep them adjusted to suit changing circumstances. After a survey of a student's record it could prescribe courses to correct deficiencies, or to develop special capabilities; it could limit or extend the hours

of work required of a student to fit the needs of the individual. Disciplinary measures would properly come from this department. Questions of transfer from one department of instruction to another within the same college, or from one college to another within the same university, or from one institution to another, could be settled with more assurance of a correct decision than is now the case. Student activities both athletic and non-athletic would be under the supervision of this department.

But this rather startling list is really only the skeleton of the department, the bones of contention as we might say; the real body, the flesh and blood of the department must be the careful analysis of the individual student which shall lead to a better understanding and development of our young men and women; and the soul of the department must be the will to help, the will to break down the traditional barrier between student and master, to point the way to achievement and the sincere enjoyment in the highest degree of a life of conscientious and worthy effort.

THE TEACHING OF ENGINEERING DRAWING.

BY

CARL L. SVENSON,

Professor of Engineering Drawing, Ohio State University.

The teaching of engineering drawing can be viewed broadly by considering the aims of drawing courses. The conception of drawing as a language and its place in industrial life was well stated by James Nasmyth more than eighty years ago. We may well reflect upon these quotations from his autobiography:

"It is very strange that amid all our vaunted improvements in education, the faculty of comparison by sight, or what may commonly be called the correctness of the eye, has been so little attended to."

"Drawing is the education of the eye, it is more interesting than words. It is the graphic language."

"Mechanical drawing is the alphabet of the engineer, without this the workman is merely a hand,—with it he indicates the possession of a head."

Dean Anthony in his "Introduction to the Graphic Language," says:

"The term Mechanical Drawing has been responsible for much that has limited the field of this language to geometry and penmanship, leaving its great function, the art of expression, almost untouched. Indeed the subject can be properly taught only from the standpoint of language."

To bring out the language conception, the writer has emphasized the idea of *Translation* as follows:

—*Translation* from views to a *Mind Picture* of the *Shape.*

—*Translation* from scale drawing to a *Mind Picture* of *Size.*

The writer has considered the graphic language as applied to use in the industries, in two major divisions which are:

I. Shape Description,
II. Size Definition,

and two minor divisions,

I. Preparation for study, equipment and its use.
(To precede the major divisions.)

II. The application and idiomatic treatment of the graphic language for engineering drawings.
(To follow the major divisions.)

Briefly put:

"Drawings have two principal uses which are:

I. To tell the shape,
II. To tell the size." *

A discussion of these two divisions is given in a bulletin † issued by the Department of Public Instruction, State of Ohio, from which the following is quoted:

" A STUDY OF THE THEORY OF SHAPE DEFINITION.

"This is the division requiring the most careful thought. The shape is, of course, described by projections and here orthographic projection must be treated adequately, first as different views, without reference to the planes of projection, but followed very soon by the demonstration of the third angle. The ability to think in three dimensions, to get a clear conception of surfaces variously arranged with respect to one another and their position in space, presents difficulties for the pupil not always realized by the teacher. The apparent simplicity of orthographic projection when applied to a single rectangular block is deceptive. For this reason a nice balance of theoretical and practical subjects is necessary in order to secure the proper training, although the pupil need not know that he is studying theory, and indeed the words *orthographic projection* need not be used in class at all.

"As to problems for shape study, the progression should be—drawing from models, from pictorial views, supplying missing views or other views and from verbal description. Type solids can be used to a limited extent, but real things

* "Essentials of Drafting," 1918.

† "Mechanical Drawing for High Schools," 1919.

should predominate. Much of the study of shapes may be done by freehand sketches in order to save time.

"The change from the usual two dimensional thinking to space conception is more radical than generally assumed and particular efforts must be exerted to use subjects which will enable the pupil to get away from thinking in 'the flat.'

"A study of shape definition includes the representation and visualizing of the elementary solids and their various combinations in natural and in out-of-the-ordinary positions; the representing and visualizing of invisible parts and a clear understanding of the meaning of such representation; the representation of the interior of objects and combinations of objects by use of conventional cutting planes.

The number and choice of views as well as their arrangement should be studied and analyzed. Problems should be selected which will cover these points and in such a way that there will be an easy transition from one to the other until the subject as a whole is worked out."

"A STUDY OF THE ELEMENTS OF SIZE DEFINITION.

There is a certain lack of definiteness in the subject of dimensioning which causes it to be neglected as a grand division of mechanical drawing. It is generally treated by giving a list of rules without a complete exposition of the rules and their application. This subject should be classified as completely as orthographic projection and problems in dimensioning should be given to illustrate the elements. From the sizing of simple objects the problems should lead to combinations, with an orderly procedure of work. The systems of dimensioning should be taken up and advantages and disadvantages discussed. Dimensioning should be applied to wood, castings, forgings, and sheet metal. At the same time the machines used in the industries should be described, and the operations which are performed on them with the materials used for different purposes, should be explained. This is just as necessary for the making of intelligent drawings as for shop courses."

The first of these major divisions, shape description, has received most of the attention of teachers of drawing. A great deal of time is devoted to descriptive geometry, the theory of orthographic projection and shape description generally. The necessity for developing the ability to think in

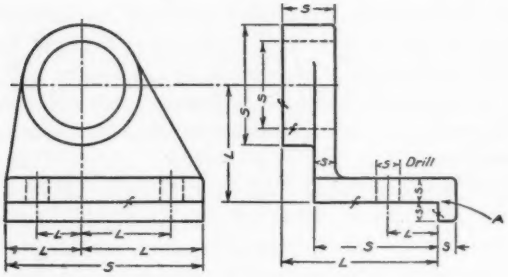
space—three-dimensional thinking—seems to be recognized as one of the primary requisites of an engineering drawing course. Included in this is the idea of size as well as shape. It seems to the writer that engineering drawing teachers should face the matter of presenting the theory and application of the principles of size definition. General rules and such statements as seek to evade the issue be declaring that dimensioning is a matter of knowledge, judgment, and shop experience and quite aside from the real issue. It is true that they are of immense value in size definition as they are likewise in shape description. But, they are no more absolutely necessary in the one case than in the other for an adequate presentation of the theoretical principles. The writer when confronted with the difficulty of teaching size specification some years ago sought an analysis based upon a system of reading drawings as taught by Dean Anthony. As developed, the principles of dimensioning were found to be surprisingly simple and easily taught. Instead of explaining to a student that there are many arrangements for describing the size of an object, he can be taught the simple principles which will result in a well and completely dimensioned drawing. His work will be definite and enjoyable and the results for a given condition will be as practically identical as in the case of shape description.

These principles have been used successfully for many years, published in one of the writer's early books and more completely presented in a more recent one.*

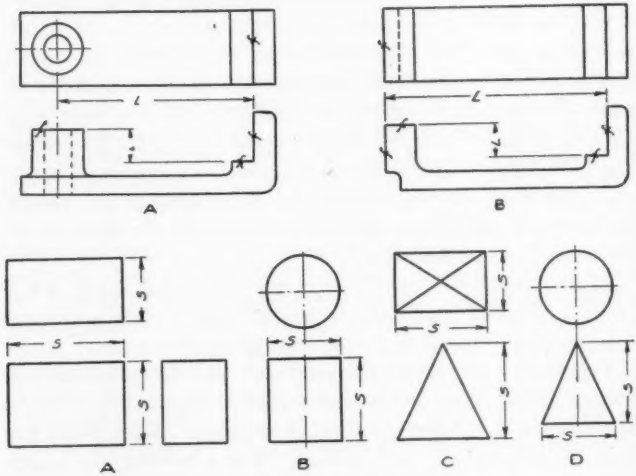
This theory may be briefly outlined. All constructions can be considered as made up of geometrical type solids or parts of such solids, either positive or negative. Each solid can then be dimensioned and located. For a rectangular prism, three dimensions are required and for a cylinder, two dimensions, diameter and length, Fig. 1. Prism type parts are located by surfaces and cylinder type parts by surfaces and axes, Fig. 2.

* "Machine Drawing."

Thus there are two major *kinds* of dimensions:



Size Dimensions (Fig. 1),



Location Dimensions (Fig. 2).

The application of these principles of the theory of size definition to a simple machine part is shown in Fig. 3, where size dimensions are indicated by the letter "*S*" and location

dimensions by the letter "*L.*" Note that the diameter and length of each cylinder is given and the dimensions of each prism. The cylinder and prisms are located with respect to each other by the center line of the left hand view and the two locating surfaces which meet at "*A*" in the right-hand view.

The analysis of a construction into its elementary parts is the first step. The second step is to dimension each elementary part. The third step is to locate the parts.

A study of the *notation of dimensioning* should precede the above theory and a study of the *cases of dimensioning* should follow it.

This brief article is not intended to do more than indicate the fundamental basis of the *Theory of Shape Definition* or dimensioning as developed and used by the writer in teaching this division of engineering drawing as a well defined subject.

NEW MEMBERS.

District No. 1

LYFORD, OLIVER S., Vice-President and Consulting Engineer, Lawrence Investing Company, 77 Kraft Avenue, Bronxville, N. Y.

ROSSMASSLER, CARL, Professor of Machine Design, Cooper Union, New York City.

KRAUSNICK, WALTER, Associate Professor of Electrical Engineering, Newark Tech. Inst., N. J.

District No. 2

SOMERS, RANSOM E., Professor and Head, Dept. of Geology, Univ. of Pittsburgh, Pa.

MCCONN, CHARLES MAXWELL, Dean, Lehigh University, Bethlehem, Pa.

KNEBERMAN, MORRIS S., Assistant Professor of Mathematics, Lehigh Univ., Bethlehem, Pa.

HALLIGAN, CLAIR WM., Instructor in Electrical Engineering, Bucknell Univ., Lewisburg, Pa.

FEY, HOWARD M., Associate Professor of Physics, Lehigh Univ., Bethlehem, Pa.

ECKFELDT, HOWARD, Professor of Mining Engineering, Lehigh Univ., Bethlehem, Pa.

OTT, PERCY WRIGHT, Assistant Professor of Mechanics, The Ohio State Univ., Columbus, Ohio.

JACKLIN, HAROLD M., Assistant Professor of Automotive Engineering, The Ohio State Univ., Columbus, Ohio.

District No. 3

KIRKPATRICK, WALTER GILL, Professor of Municipal Engineering, Univ. of Mississippi, University, Miss.

District No. 4

CANFIELD, DONALD T., Instructor in Electrical Engineering, Purdue Univ., Lafayette, Ind.

STEWART, EARL A., Associate Professor of Agricultural Engineering, Univ. of Minn., Minneapolis, Minn.

TEETER, THOMAS A. H., Associate Professor Engineering, Univ. of Minnesota, Minneapolis, Minn.

WATTS, OLIVER P., Associate Professor of Chemical Engineering, Univ. of Wisconsin, Madison, Wis.

District No. 5

CHEN, YUFONG, President, Kiangsen Technical College, Fu-Chen Bridge, Nanking, China.

SECTIONS AND BRANCHES.

The second meeting of the year of the **Case Branch** was held in the Case Club on Tuesday evening, March 3, 1925, with twenty-nine members present. After a cafeteria supper, the meeting was called to order at 6:30 by Professor Eddy, who introduced Professor Dates, the speaker of the evening.

Professor Dates spoke upon "The Use of Standard Tests in Engineering Colleges." He pointed out some of the objectionable features in the ordinary method of grading and stated that the primary objection is the lack of a standard scale for measurements. Other objections mentioned were: the lack of a zero starting point, and the fact that grading is influenced by the instructor's personal opinion. He said, "The function of a measure is to determine the knowledge of and the ability to think in the material of the course."

Professor Dates, who is the head of the Electrical Engineering Department, then gave some of the experience his department has recently had in the use of tests of the true-false, recognition and completion type, and seemed to feel that the results were, on the whole, quite satisfactory and as far as his department was concerned, would be given further trial.

President Howe gave some indications of present day tendencies in tests of the above nature and recommended their consideration and trial by other departments.

After a lively discussion by several of the members, the meeting adjourned at about 8 o'clock.

W. E. NUDD,
Secretary.

North Carolina Section.—The third meeting of the college year was held in the evening of March 13 at Trinity College of Duke University, Durham. Before the meeting the Section had a supper in conjunction with the North Carolina Physics Teachers Association which had held its annual meeting at Duke University in the afternoon. At the S. P. E. E. meeting there was an attendane of twenty-three in-

cluding some of the members N. C. Physics Teachers Association.

The subject for the evening was "Physics for Engineers," continuing the line of thought started at the preceding meeting at which "Mathematics for Engineers" was discussed. The Program Committee had a speaker from each of the institutions constituting the Section:

Prof. C. M. Heck of N. C. State College of Agriculture and Engineering.

Prof. C. C. Hatley of Duke University.

Prof. E. K. Plyler of the University of North Carolina.

Following the three scheduled talks a general discussion of the subject was held, during which the relative merits of the Metric and English Systems of measurement were vigorously debated.

D. C. JACKSON, JR.,
Secretary.

The **Purdue Branch** of the S. P. E. E. held its final meeting for the present school year on the evening of Thursday, April 23. This meeting was in charge of the English Department; the general subject for consideration being English as Related to Engineering Education.

Papers as follows were presented:

Literature by Prof. R. A. Cordell,
Composition by Prof. J. H. McKee,
Public Speaking by Mr. P. H. Scott.

A very interesting and helpful discussion followed the presentation of these papers, the effect being to give members of other schools and departments a better idea of the aims and ideals toward which the English department is working—and also to bring into the limelight some of the problems encountered by this department.

Prof. J. A. Needy was elected for the ensuing year.

Attendance 25.

G. C. BLALOCK,
Secretary.